ETHERS, RELIGION AND POLITICS IN LATE-VICTORIAN PHYSICS: BEYOND THE WYNNE THESIS

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1. INTRODUCTION

In the past thirty years historians have demonstrated that the ether of physics was one of the most flexible of all concepts in the natural sciences. Cantor and Hodge's seminal collection of essays of 1981 showed how during the eighteenth and nineteenth centuries British and European natural philosophers invented a range of ethers to fulfil diverse functions from the chemical and physiological to the physical and theological.[1] In religious discourse, for example, Cantor identified "animate" and spiritual ethers invented by neo-Platonists, mystics and some Anglicans to provide a mechanism for supporting their belief in Divine immanence in the cosmos; material, mechanistic and contact-action ethers which appealed to atheists and Low Churchmen because such media enabled activity in the universe without constant and direct Divine intervention; and semi-spiritual/semi-material ethers that appealed to dualists seeking a mechanism for understanding the interaction of mind and matter.[2] The third type proved especially attractive to Oliver Lodge and several other late-Victorian physicists who claimed that the extraordinary physical properties of the ether made it a possible mediator between matter and spirit, and a weapon in their fight against materialistic conceptions of the cosmos.[3]

Lodge was, of course, one of many late-nineteenth century British physicists who were involved in psychical research. More physicists than representatives of other scientific disciplines reached senior positions during early decades of the Society for Psychical Research (SPR), that symbol of the Victorian intellectual preoccupation with the occult which was founded in 1882. The SPR boasted Balfour

Stewart, William Crookes, William Fletcher Barrett, and the Third Baron Rayleigh as presidents, J. J. Thomson as a vice-president, and Arthur Chattock, Arthur Schuster, W. C. D. Whetham and many other physicists as ordinary members. It is tempting to think that physicists' marked interest in the mysterious, and typically invisible and imponderable phenomena, of psychical research was linked to their adherence to the hypothesis of an invisible and imponderable ether. Connections between the ether and the kind of phenomena studied by late-Victorian psychical researchers certainly had some pedigree. From the mid-nineteenth century many spiritualists speculated that "spiritual" ethers or ethereal elements were involved in the production of clairvoyance, telekinesis, and the manifestation of spirits, and they championed physicists' conception of the ethereal basis of matter as a sign that science in general and physics in particular was becoming spiritualistic.[4] But to what extent did the ether constitute a link between physicists and psychical research?

One of the most provocative and widely-cited attempt to explore the "physics and psychics" connection was Brian Wynne's contribution to Barry Barnes and Steven Shapin's *Natural order* (1979), a groundbreaking collection of essays exemplifying the ways in which the Sociology of Scientific Knowledge developed by the Edinburgh School could deepen the understanding of various episodes in the history of science.[5] As with all members of the Edinburgh School, Wynne sought the social determinants of the content of scientific knowledge. He argued that the reason why late-Victorian physicists adhered so strongly to their conception of an immaterial ether and became involved in psychical research was because both enterprises tacitly expressed the conservative moral and social views of a Cambridge intellectual elite with whom the physicists were closely connected: by evincing an unseen spiritual domain that gave unity and meaning to the material cosmos, physicists produced a

powerful natural symbol of the desired unity of the social world that conservative dons believed was fragmenting under the forces of industrialisation and secularism. However, when Wynne's paper was republished in 1982 it was severely criticised by Bruce Hunt for containing serious errors of historical fact and interpretation.[6] Wynne later admitted to the mistakes but maintained that the "kernel" of his paper, the coupling of "scientific arguments and commitments" with "social concerns", remained valid.[7] As Cantor and Hodge's collections shows, the religious and social uses of the ether have a long history and for this reason the "kernel" of Wynne's paper remains plausible and certainly worthy of further consideration.

This paper shows that in their uses of the ether late-Victorian physicists did more than tacitly express religious and social arguments articulated forcefully by statesmen, intellectuals and other non-scientific Victorians: the ether was frequently an *explicit* part of physicists' engagement with a range of metaphysical and political discourses. The first half of the paper comprises a detailed assessment of Wynne's thesis. Sections 3–6 challenge four of his major claims: first, that there existed a well-defined "Cambridge School" of physics who were intimately linked to leading conservative statesmen and intellectuals; second, that the specifically "immaterial" ether captures the flavour of the work of these physicists and that "technical" grounds were the most important grounds of justifying this hypothesis; third, that psychical research was dominated by Cambridge physicists; and fourth, that the ether was opposed to major aspects of "scientific naturalism" including a "non-ether" cosmoslogy, the industrialisation of British education, the professionalisation of the sciences, and precision measurement.

The second half of this paper moves well beyond Wynne's thesis by abandoning the exclusive focus on genuine Cambridge physicists and immaterial

ethers. By considering physicists from inside and outside the Fenland university, by looking at individuals who believed the ether was unlike ordinary matter but still possibly material, and by documenting rather than simply inferring the *different* positions held by physicists on a range of important religious and political issues, I support a new thesis that the ether was actively, not just tacitly, used by physicists to express different religious and political views, some of which they shared with conservative thinkers. The broad consensus among late-Victorian physicists that the ether had to be unlike ordinary matter and had other extraordinary physical properties — quasi-immateriality, universality, continuity and unity — made it a particularly flexible resource for physicists engaging in religious and political discourse. It was these supposed properties of the hypothetical ether that made it a plausible argument against a determinist and materialist cosmology, a way of comprehending Divine intelligence and providence, a mediator between the terrestrial and spiritual existences, as well as a metaphor of Tory and Unionist views of the British empire, socialist views of wealth, and the spirit of international cooperation.

In showing how new historical research and analysis takes us beyond Wynne's thesis, this paper historicises the latter work as an example of the Edinburgh School's approach to the history of science developed some thirty years ago. Much of this paper, and the secondary sources on which it draws, builds implicitly on the Edinburgh School's important claim that all knowledge, whether scientific or non-scientific, true or false, is to one degree or another shaped by social factors. But social and cultural histories of science have moved on considerably since the late 1970s, turning away from the Edinburgh School's focus on macroscopic social causes of scientific knowledge to more localised, nuanced and more satisfactory notions of what was "social" in the production of scienitifc knowledge.[8] As Golinski has shown,

the more recent historical projects show that history is not simply "sociological theory put into practice" and qualify such "abstract formulations" as the Strong Programme with empirical findings which force a "more subtle awareness of the complexities of the sciences as creations of human culture".[9] This paper is a call for just such awareness in the interlinked worlds of late-Victorian physics, religion and politics. Detailed historical probing shows how difficult it is to explain the production of and adherence to particular forms of knowledge (the ether) by large-scale social factors (intellectual life at Victorian Cambridge and Conservative politics) and forces us to be sensitive to the subtly different social and religious views held by physicists and to the subtly different uses of the ether prompted by such views.

2. THE WYNNE THESIS

Wynne's paper centred on the activities of late-Victorian physicists that he identified as the "Cambridge School" because the former were "dominated by Cambridge and recent émigrés from Cambridge to the provinces".[10] He insisted that one of the most "distinctive" intellectual features of this school was its view that ether was a non-material substance superior to and constitutive of ordinary matter, a conception inverting the older idea that the ether was an elastic solid or some other material substance that could be easily comprehended.[11] Crucially, this ether was "a construction which other physicists did not deem to be required by the technical state of their discipline" from which Wynne concluded that technical factors cannot help us understand why so many Victorian physicists adhered to the construction.[12] However, Wynne held that the social context of late-Victorian Cambridge can help us understand physicists' attachment to this ether conception and a range of other

"concepts and principles", such as the need for unifying principles in the sciences, a hostility to the "positivistic and naturalistic" abolition of entities that defied empirical observation, and the importance of imagination over precision measurement.[13] In late-Victorian Cambridge these concepts and principles seemed to take on additional importance because they provided a natural analogy for or symbols of the social, political and religious outlook of a conservative intellectual elite. Leading dons such as F. D. Maurice, J. R. Seeley, and Henry Sidgwick feared the moral declination and social chaos following industrialisation and the naturalistic worldview that underpinned it: industrialisation seemed to be making Britons more materialist, utilitarian and socially divided; "scientific naturalism" was divorcing scientific knowledge from metaphysics and turning the cosmos into a bleak mechanism of isolated material atoms in motion, a move vanquishing the very transcendental reality that many considered gave the universe meaning and unity; and intimately related to this cosmical view was scientific naturalists' social view in which power was taken from traditional authorities — Oxbridge, the Anglican Church, and the aristocracy — and given to professional scientific practitioners whose amoral, materialist, secular and utilitarian view of nature made them the ultimate servants of the increasingly powerful industrial bourgeoisie.[14]

In response, Cambridge intellectuals sought "a new, unifying intellectual universe to underpin a revamped moral and political universe of unity and harmony".[15] They needed to know that the "organic unity" and the "unseen, 'spiritual' aspects of nature" was a plausible claim because this justified and symbolised the typical response of conservative intellectuals to bourgeois individualism — the need to maintain the "organic ties of society" and the "ineffable and transcendent basis of social reality".[16] Wynne noted the "striking analogy"

between this social vision and Cambridge physicists' belief in an immaterial ether that was superior to and gave unity to the physical universe, and sought two types of evidence for the ether being used as a "'natural law' witness" to a desired social and moral order, and thus a reason why this item of natural knowledge proved so enduring.[17] First, Wynne attempted to show that the "dominating elite" of British physics shared some of the moral and social views of conservative thinkers because both groups participated in the SPR's attempts to evidence the unseen spiritual world beyond matter. The SPR, in fact, was one of many ways in which physicists were "intimately connected, socially and intellectually, with the elite of conservative politics and of moral and political philosophy" which Wynne offers as tangential evidence for physicists' ether theorising being an implicit form of the moral and social discourse engaged in more explicitly by their non-physicist peers.[18] Second, Wynne shows how Lodge and several other "Cambridge School" physicists entered the fight against materialism by explicitly using the ether in an argument for the reality of mind and spirit in the cosmos, and thus as a support for the established moral and social order. Primarily on the basis of these two types of evidence, Wynne concluded with the tentative suggestion that he had shown how "concepts and principles of a science were developed and sustained not only (or perhaps not even) for their technical value, but very much also for their social value".[19]

3. THE "CAMBRIDGE SCHOOL" OF PHYSICS

The major weakness of Wynne's thesis is its notion of a "Cambridge School" of physics, a term to which I shall occassionally refer throughout this paper in the sense that it was originally, albeit problematically, used. Wynne is right to emphasise the

importance of the colleges and University of Cambridge in training and employing some of the most illustrious figures in late-Victorian physics and he rightly locates the 3rd Baron Rayleigh, J. J. Thomson, G. G. Stokes, Joseph Larmor, James Clerk Maxwell, P. G. Tait, William Hicks, and J. A. Fleming in this "Cambridge School". They all read for the Cambridge Mathematical Tripos which made them particularly sympathetic to the idea of an ethereal continuum for carrying light waves: this training privileged the wave (rather than the emission) theory of light thus justifying the need for a luminiferous ethereal medium in which waves propagated; and it provided students with a range of techniques in continuum mechanics which could be plausibly applied to optics and, following Maxwell, electromagnetism, if such aspects of the physical world were treated as consequences of an ethereal continuum.[20] However, as Hunt showed and Wynne later admitted, this conception of a "Cambridge School" is undermined by major factual errors.[21] William Fletcher Barrett, George Francis FitzGerald and Balfour Stewart were not, as stated, Fellows of Trinity College, Cambridge, and they did not have strong associations with Cambridge: Barrett was trained at the Royal Institution under John Tyndall, and in 1873 became Professor of Experimental Physics at the Royal College of Science for Ireland in Dublin; FitzGerald was educated and spent his career at Trinity College Dublin whose mathematical tradition had some links with Cambridge, but was much more accommodating than the Fenland varsity of Continental techniques; and Balfour Stewart was educated in Edinburgh University and in 1870, after a long stint as Superintendent of the Kew Observatory, became Professor of Natural Philosophy at Owens College Manchester.[22] The Third Baron Rayleigh and F. D. Maurice *were* Fellows of Trinity College Cambridge but neither became college masters, an error

that also makes the connection between late-Victorian physics and Trinity stronger than it actually was.

The errors concerning Barrett and Stewart are doubly troublesome to Wynne's argument because it is with their belief in an unseen universe evinced by physics that he wants to show the spiritual and anti-materialistic uses to which the "Cambridge School" were prepared to put physics. The error concerning FitzGerald causes the additional problem that it is via him that Wynne wants to link Lodge to the "Cambridge School". Apart from a research trip to the Cavendish Laboratory in the summer of 1889, Lodge's expertise in physics owed little to Cambridge: his scientific training took place in London colleges and his career was spent outside Oxbridge, as Professor of Physics and Mathematics at University College Liverpool (1881–1900) and then Principal of Birmingham University (1900–1919).[23]

The friendships between non-Cambridge and Cambridge physicists — notably, Barrett with Stokes, FitzGerald with Larmor and William Thomson, Lodge with Larmor, Rayleigh, and J. J. Thomson, and Stewart with Maxwell, Tait and J. J. Thomson — certainly makes it possible to speak of a network of late-Victorian physicists with Cambridge as an important node. But "Cambridge School" remains a misleading and unsatisfactory analytical category because its members did not share a Cambridge educational background and thus employed different techniques to solve scientific puzzles and had different ideas regarding which puzzles were important for scientific analysis: Lodge's approach to Maxwellian electrodynamics, for example, depended strongly on constructing conceptual and table-top models, rather than the abstract mathematical and analytical-dynamical approach of such Cambridge wranglers as Larmor and J. J. Thomson.[24] Another person whose scientific education and career places him even further from the worlds of Cambridge physics is William

Crookes. Trained in the Royal College of Chemistry, this leading analytical chemist and science journalist spent much of the early 1870s producing evidence for what he believed to be spiritualist mediums' genuine capacity to exude a "psychic" force and to materialise "spirits", and he was an early explorer of the hazy boundary between matter and radiation suggested by experiments on the discharge of electricity through rarefied gases.[25] Wynne rightly points out that that this "shadowy" world between ordinary matter and the ether was "central" to Cambridge physics — notably, the Electronic Theory of Matter developed by Larmor and his students, and the experimental investigations of Thomson and his Cavendish students into cathode rays, X-rays, and other phenomena produced by the electrical discharge through rarefied gases. However, this scientific preoccupation was not unique to Cambridge.[26] Crookes was one of several scientific practitioners well outside this university — for instance, FitzGerald, Hugo Müller, Warren De La Rue, William Spottiswoode and Cromwell Varley — who exploited electrical discharge as a powerful tool for probing the boundary between matter and ether.[27]

The notion of a coherent "Cambridge School" also breaks down on closer analysis of the views of genuine Cambridge physicists. As several historians have shown, despite being exact contemporaries in the 1880 Cambridge Mathematical Tripos, Larmor and J. J. Thomson came to represent the different approaches to electrodynamics adopted by the increasingly distinct corps of experimental and mathematical physicists.[28] By the early 1900s, members of the research school in experimental physics that Thomson directed at the Cavendish Laboratory were dominated by individuals trained in the natural sciences rather than mathematics and took little interest in the Electronic Theory of Matter or other abstract advances in electrodynamics produced by Larmor and other theoreticians. There was also a lack

of consensus among genuine Cambridge physicists on scientific naturalism, psychical research, and as we shall see in the next section, the constitution of the ether. The "School" that produced Rayleigh and Thomson also produced William Thomson, who was bitterly hostile to psychical research and scientific naturalism, and John Fletcher Moulton and John Henry Poynting, who were sceptical of most hypotheses of ether and of the microscopic nature of matter, and uninterested in psychical research.[29] It also produced William Kingdon Clifford, the mathematician notorious for his championing of secular ethics and naturalistic cosmology, as well as one of the most potent attacks on the argument in Stewart and Tait's *Unseen universe*; *or, physical speculations on a future state* (1875) that conceptions of ether and matter were compatible with Christian supernaturalism.[30]

The relocation of Barrett, Crookes, FitzGerald, Lodge, and Stewart outside Cambridge also weakens the "intimate social connections" that Wynne supposed existed between leading physicists and the "upper-class Cambridge intellectuals" who felt so strongly about the effects of industrialisation.[31] We can no longer *assume*, therefore, that these physicists would have shared the moral and political views of the conservative intellectuals whom they would otherwise have met at college high tables or in senior combination rooms. Accordingly, we cannot assume that their positions on the ether and psychical research somehow expressed the moral and political views of these dons. These physicists moved in different social and intellectual, let alone geographical, circles from those of Cambridge intellectuals. The worlds of Barrett, Crookes, FitzGerald, Lodge and Stewart were at least as close to those of the "scientific professionalisers" than the Cambridge savants: these were predominantly bourgeois, metropolitan and industrial landscapes featuring quests for scientific and technical instruction, grubby experimental physics laboratories, popular lecturing, and

new scientific societies. As Wynne shows, Lodge overcame this geographical and social distance from Cambridge through regular correspondence and meetings with the Larmor, and the Cambridge-educated intellectuals at the SPR, including the philosophical writer and Tory statesman Arthur Balfour, the essayist and schools' inspector F. W. H. Myers, and the moral philosopher Henry Sidgwick.[32] Nevertheless, as I seek to show, we can gain a more satisfactory insight into the extrascientific uses to which physicists put the ether once we document and analyse their religious and political interests, rather than merely infer such interests from physicists' known connections with statesmen, intellectuals and other non-scientific Victorians.

4. CAMBRIDGE AND THE ETHER

Problems of historical fact and interpretation also undermine Wynne's notion that the "Cambridge School" developed a distinctive view of the ether that could be used in the fight against naturalistic cosmology and bourgeois industrial morality. Following earlier analysis, many of the late-Victorian physicists responsible for promulgating the view that the ether was a medium distinct from and superior to ordinary matter — notably FitzGerald and Lodge — were not Cambridge savants. Furthermore, as Hunt pointed out, Wynne erred when he claimed that scientific naturalists believed that the conservation of energy applied to matter alone: most scientists, the naturalists included, insisted that energy had to be exchanged between matter and ether, not least because this was how we experienced the heat and light from the sun even though it was separated from the earth by empty space.[33] Far from adopting a "non-ether" approach, scientific naturalists were among the most renowned promulgators of the scientific hypothesis.[34] In 1871, for instance, John Tyndall preached that the ability

of the undulatory theory of light to account for "[t]housands of isolated facts" was the reason why the "foremost men of the age accept the ether not as a vague dream, but as a real entity — a substance endowed with inertia, and capable, in accordance with the established laws of motion, of imparting its thrill to other substances".[35] Tyndall thereby showed the extent to which scientific naturalism could, *pace* Wynne, embrace "entities whose existence could not be empirically observed". Indeed, the vigour with which Tyndall embraced the ether may well have shaped the early understanding of the ether of two budding physicists who attended the Royal Institution professor's lectures in the 1860s: Barrett and Lodge.[36] Wynne presents compelling evidence for the belief, voiced by Cambridge and non-Cambridge men, in an ether that gave underlying unity to the visible cosmos and was distinguished from ordinary matter. The Cambridge physicist who most accurately fits this description is Larmor who, in a much-cited footnote his magnum opus *Aether and matter* (1900), declared that "Matter may be and likely is a structure in the 'aether', but certainly aether is not a structure made of matter", and elsewhere distinguished this "aether" from all "material media" and defined it as the "ultimate medium" for connecting all physical phenomena under dynamical and energetic principles — a "pure *continuum* of which elasticity, inertia and continuity of motion, are the sole ultimate and fundamental properties".[37] It was this notion of a ether — one that was purely dynamical, physical and non-material and which could not legitimately be represented in terms of any known mechanical medium — that was developed by Ebenezer Cunningham and other Larmor students, and by several other major physicists elsewhere in Britain and on the Continent.[38]

But many of Larmor's Cambridge colleagues and physicists further afield still spoke of the ether as "material" or as part of the "material universe" even though they

argued, in opposition to that illustrious proponent of the elastic solid model of the ether, the Cambridge-trained William Thomson, that this material could not be the same as that which constituted ponderable matter because the ether required extraordinary inertia and could neither exert nor respond to gravitational force. In the late-Victorian period Barrett, Stewart, Stokes, and J. J. Thomson all spoke of the ether as a material medium of a different and higher order than that of ordinary matter.[39] FitzGerald and Lodge occupied more ambiguous positions on the materiality of the ether. Stein has suggested that FitzGerald may have been critical of William Thomson's view that the ether was like the ponderable matter of an elastic solid, but he did not rule out the possibility that the ether was in some sense material.[40] FitzGerald was never satisfied with Larmor's abstract dynamical ether and preferred models embodying more concrete mechanical conceptions, such as his vortex sponge model of the ether in which ordinary matter and the ether were reduced to forms of pure motion in a universal incompressible fluid medium.[41] Lodge's apparent refusal to fully embrace the idea of totally abstract immaterial ether was noted by one reviewer of the physicist's first book-length exposition on the subject, *Ether of space* (1909).[42] Indeed, Lodge's writings from this and subsequent decades show a clear rejection of the old elastic solid ether but a refusal to relinquish the idea of ether as the mechanical reality underlying nature, and a corresponding recognition of the problems of using such terms as "material" to describe such a medium. Thus, in his famous presidential address on "Continuity" to the 1913 meeting of the British Association, he insisted that "Matter [the ether] is not, but material it is" although twenty years later he characterised the ether as an "extraordinary non-material but physical substance".[43] The problem for physicists such as FitzGerald, Lodge and J. J. Thomson was that to satisfy their quest to relate ether models to mechanical

conceptions they were forced to speak of the medium as in some sense material. For this reason Lodge worried later in his career that "the properties of the ether are not likely to be expressible in terms of matter; but, as we have no better clue, we must proceed by analogy, and we may apologetically speak of the elasticity and density of the ether as representing things which, if it were matter, would be called by those names".[44]

The ether's materiality did not preclude its theistic uses. As we shall see in more detail later in this paper, what seemed to matter to late-Victorian physicists who envisioned religious uses of the medium was that it was vastly different from ordinary matter and thus could fulfil symbolic and literal roles in linking the domain of the material to that of the spiritual. One leading American physicist neatly captured the situation in 1899 when he explained that because the constitution of "imperceptual ether" differed so greatly from "perceptual matter", "materialistic philosophers" were mistaken in their attempts to apply the laws of matter to ether and why it was folly to rule out the possibility of other phenomena, including miracles, that violated the laws of ponderable or ordinary matter.[45]

The difference of opinion among British physicists, let alone Cambridge physicists, about the constitution of the ether causes problems for Wynne's crucial claim that the Cambridge ether was a construction that "other physicists did not deem to be required by the technical state of their discipline".[46] Since there was no unique "Cambridge" ether it is difficult to identify the non-Cambridge physicists who objected to it on technical grounds: Larmor's conception of the ether, for example, does not seem to have interested J. J. Thomson or many of Thomson's cadre of experimental physicists.[47] Moreover, as Warwick has pointed out, Wynne's claim wrongly implies that since Einstein and his followers had made the notion of a

dynamical ether superfluous to the practice of electromagnetic theory, then British physicists' continued use of the concept was aberrant and in need of "some kind of *special* social explanation in terms of British culture".[48] Warwick rightly avoids privilege the relativistic "winners" over the etherial "losers" and emphasises the central place that the ether occupied in practices of British electromagnetic theory, and why those "professional technicians of the ether", the British Maxwellian experimenters and theoreticians for whom the ether was a "form of physical currency" and who had invested so much of their scientific careers in the concept, found Einstein's arguments hard to accept.[49] We shall see that aspects of the religious and political context do explain the some of uses to which some British physicists put the ether, and that these may well have raised physicists' belief in the medium; but these were not as important as a host of other reasons — aesthetic, empirical, "philosophical", and physical — that physicists explicitly gave for adhering to the ether and which underpinned their hostility to those champions of Einstein who turned relativity theory into a potent argument against the ether. The remainder of this section surveys these reasons.

The luminiferous ethers of Christian Huygens, Augustin Jean Fresnel and others were regarded as necessary consequences of the wave theory of light, and the hypotheses of dynamical ethereal continua developed by Maxwell and his interpreters were developed to explain how electromagnetic energy, of which light was one form, was propagated from one place to another at finite speed. The most important empirical victory for Maxwellian conceptions of the ether came from Germany — where action-at-a-distance theories of electrodynamics held sway — in the form of Heinrich Hertz's experimental demonstration, in 1888, of the production of unbounded electromagnetic waves travelling at the speed of light.[50] This bolstered

the confidence of British physicists in existence of an ethereal continuum, a confidence that was not shattered by their failure to develop a satisfactory model — whether mechanical or electromagnetic — of an ether that would eventually accommodate such extraordinary physical properties as enormous inertia, gravitation, and apparent capacity to be totally undisturbed when moving matter passed through it. By the end of nineteenth century, however, the ether remained one of the most intractable puzzles in physics. As the Trinity College Dublin physicist Thomas Preston explained in his *Theory of light* (1895), the existence of the ether could only be established by the "intellect" rather than direct sensory experience, its connection with ordinary matter was "far from being settled by experiment", and that there were "difficulties […] in forming a consistent idea" of its constitution and functions.[51] But like many other British physicists, Preston remained confident that an ether was required by the evidence of the propagation of all types of energy. Well into a period when many physicists had followed Einstein in regarding the ether as superfluous to solving puzzles in electrodynamics, several British physicists insisted that the ether still provided more satisfactory answers to "philosophical" questions than did the notion of direct action across void space. By the early 1910s, not long after he had first begun attacking relativity theory, Larmor insisted that it was our familiarity with the transmission of physical action "after the manner that a continuous material medium, solid or liquid, transmits mechanical disturbance", and the

> exact analyses of them which the science of mathematical physics has been able to make, that our predilection for filling space with an aethereal transmitting medium, constituting a material connexion between material bodies, largely depends; perhaps ultimately it depends most of all, like all our physical conceptions, on the intimate knowledge that we can ourselves exert mechanical effect on outside bodies only through the agencies of our limbs and sinews.[52]

It was for just such reasons that those elder statesmen of British physics, Larmor, Lodge, and J. J. Thomson, shared Einstein's own view that the General Theory of Relativity had not killed off the ether *per se*, but reinvented it as the physical structure of space, a conception needed for the propagation of light and to give meaning to the measurement of space-time intervals, and to the very ideas of space and time.[53] Lodge spoke for an increasingly rarefied group of physicists when in the early 1930s he explained that "It is quite true that physical calculations and discoveries can proceed without explicit reference to the ether, but when we come to philosophise and try to formulate the facts physically, it is clear that space must be endowed with physical properties and is therefore entitled to something more than a merely geometrical name".[54] For Lodge and his allies, the cosmos was simply easier to comprehend on the basis of an ether.

These philosophical and physical grounds for believing in an ether were reinforced by a host of other arguments. As Morus points out, physicists' and electrical engineers' belief in the reality of the intangible medium was underpinned by their ability to measure its electromagnetic characteristics properties to extraordinary precision and to manipulate it — notably, in sending wireless telegraphic signals through space.[55] Its very simplicity also conferred epistemic value. In 1884 Stokes explained that it was by "finding with what admirable simplicity [the phenomena] of light are explained by the supposition of the existence of an ether, that we become convinced that there is such a thing", and Larmor was even more forthright when a few decades later he insisted that "the only ground for postulating the presence of [the aether] is the extreme simplicity and uniformity of the constitution which suffices for its functions".[56] The ether's apparent simplicity was also the reason why it was so useful to physicists. The "possibility of a science of physics", Larmor urged in 1900,

"is largely due to the simplicity of constitution of the universal medium through which the individual atoms interact on each other".[57]

Finally, the ether was useful because it gave physicists a tool for supporting their belief in the unity of nature and of the sciences.[58] In 1913, when relativity was being explicitly used to undermine the ether and the Electronic Theory of Matter on which he and fellow Maxwellians had invested so much time and effort, Lodge retorted that the ether was the "great engine of continuity" because it was "the uniting and binding medium without which, if matter could exist at all, it could exist only as chaotic and isolated fragments".[59] The cosmos was easier to understand, in other words, if there was an etherial realm transcending gross matter. The ether was not only valuable to Lodge and other Maxwellian practitioners because they had been trained to regard it as something that gave meaning and unity to a wide variety of physical phenomena but because it allowed them to translate their authority in electrodynamics to other areas of scientific enquiry. In the 1880s and 1890s, for example, it had helped Maxwellians annexe optics to electrodynamics and constituted the links in what Lodge boastfully called the "imperial science of electricity".[60] Attempts to extend the ethereal empire were justified because this had been a major source of intellectual progress and because this would stop the sciences from fragmenting into a group of isolated enterprises. Thus Lodge explained in 1908 that "most theoretical advance and discovery" in electrodynamics "has been along the continuous and medium line, which, if not the line of ultimate explanation, is at any rate that of achievement" while over a decade earlier FitzGerald had insisted that it was the study of topics common to all scientific subjects — "the study of the properties of each kind of matter as related to energy and the ether"— that made it

possible to thwart the "undue development of specialisation" which itself threatened the progress of the whole scientific "system".[61]

5. CAMBRIDGE AND PSYCHICS

Wynne"s contention that the "dominating elite of British physics was actively involved in psychical research" receives some support from the fact that Barrett, Crookes, Lodge, and Rayleigh, Stewart and Thomson occupied senior positions within the SPR.[62] However, there are at least four ways in which the picture of Victorian "physics and psychics" is much more complicated than that which portrays Cambridge physicists as active collaborators with Sidgwick and others on evidence o for alleged psychic phenomena and interventions from the spirit world. First, the SPR's membership lists are not reliable sources of gauging the activity of physicists or, for that matter, anyone else in psychical research. Many physicists were appointed to senior SPR positions for adding intellectual lustre to the society rather than for being "actively involved" in the society's research output. This is particularly the case with two of the leading Cambridge-trained physicists in the SPR, Rayleigh and J. J. Thomson, who maintained a deep interest in the society's work but conducted only occasional investigations into psychical phenomena.[63] Second, and more troubling for the Cambridge-focus of Wynne's argument, is that while the early SPR was dominated by Cambridge-educated and Cambridge-based intellectuals (notably, F. W. H. Myers, Henry and Eleanor Sidgwick, and Edmund Gurney), by far the most active of its *physicist* members were Barrett, Crookes, Lodge, and Stewart who as we have seen were not Cambridge men and only two of whom (Lodge and Stewart) were renowned for their belief in the ether.[64] Third, and conversely, there were plenty of

leading Cambridge physicists who were either hostile or indifferent to psychical research. In 1893, responding to a call for their opinion on the scientific study of occult phenomena, William Thomson charged that "nearly everything in hypnotism and clairvoyance is imposture and the rest bad observation" and Stokes, a devout Evangelical Anglican charged that the "natural immortality of the soul" implied by spiritualism was "false theology, and is indirectly responsible for not a little infidelity" while the very investigation of "occult manifestations" was unlawful.[65] As an undergraduate James Clerk Maxwell expressed interest in the "important discoveries" that might be made on investigating the possible communion of minds through some "spiritual medium" but his refusal to embark on any such enquiries owed much to his deep scepticism of "money-making media" and belief that science was impotent to deal with the question of what happened to the human personality following bodily death.[66] One of Maxwell's most important interpreters, Joseph Larmor, was slightly more sympathetic to such controversial scientific investigations. He occasionally discussed psychical matters with his friend Lodge but never joined the SPR and confessed to having a "prejudice" against the existence of apparitions of the dying, a topic on which the SPR devoted much of its attention. Despite being on the same campus as Henry Sidgwick, Larmor "viewed him from a long way off" and remembered only once coming into contact with that key figure in the SPR.[67] The examples of Larmor, Maxwell, Stokes and William Thomson are especially awkward for Wynne's thesis because they represent leading Cambridge developers of ether theories who had little or nothing to do with psychical research.

The fourth and final reason why it is implausible to characterise psychical research as the province of "dominant" or elite Cambridge physicists is the interest shown in this topic by other and less "élite" physicists elsewhere in Britain. This

interest varied from those who actively investigated telepathy and spirit-rapping to those who took only an "armchair" interest in the SPR's work and occasionally discussed psychical matters with the likes of Barrett, Crookes, and Lodge. Particularly active was Arthur Chattock, professor of physics at University College Bristol, who joined the SPR in 1890 and later staged numerous tests of his and his students' abilities to achieve telepathic communion.[68] Less active but still interested was FitzGerald who lent the SPR informal assistance on cases of apparitions, the luminous manifestations of Karl von Reichenbach's "odic" force, and levitation, but who maintained that it was "physicians not physicists" and those with "a sound scientific scepticism" rather than occultists who were the proper investigators of phenomena that he thought bordered on hysteria and lunacy.[69] Oliver Heaviside, John Perry, and Silvanus Thompson were deeply deep sceptical of spiritualism and, like FitzGerald, did not join the SPR or any other psychical research organisation. However they all showed more sympathy for the SPR's work than did Larmor, Stokes and William Thomson: despite lambasting two spiritualists he had met as "asses" who "talked a lot of bastard science" Heaviside was prepared to speculate on the possibility that high-frequency electromagnetic gave a physical basis to telepathy, Perry was convinced by the SPR's evidence of telepathy but considered some psychical researchers (including Barrett) too credulous and psychical research too metaphysical to be regarded as scientific, and Thompson regularly perused the SPR's publications and put one of its research topics — human sensitivity to magnets — to experimental test.[70]

The foregoing analysis shows that the "physics and psychics" connection in late-Victorian Britain was a good deal more complex than Wynne claims. I do not doubt that psychical research in general was an important meeting place for different

Victorian intellectuals to exchange their views on the spiritual and unseen domain beyond matter, but I disagree that the most active physicists in this enterprise can be characterised as genuine Cambridge savants with particular attachments to the ether. With the notable exception of Lodge, the savants who most strongly link "physics and psychics" were nowhere near as concerned with the ether as were FitzGerald, Larmor and Stokes and wrote no more on the subject than that notorious sceptic of spiritualism — Tyndall. Conversely, Larmor, the British physicist who was largely responsible for the dematerialisation of the ether, showed little interest in psychical research. This does not mean that the physicists who had nothing to do with psychical research did not claim psychic or spiritual functions for the ether. As we shall see, Lodge's invention of an "etherial body" to explain evidence of the survival of the personality following bodily death was one of many different ways in which the ether was used by late-Victorian physicists in arguments against materialistic conceptions of the universe.

6. THE "CAMBRIDGE SCHOOL" VERSUS SCIENTIFIC NATURALISM

One of the biggest appeals of psychical research to physicists and other Victorians was its promise of evidence of the independence of mind and body and the survival of the human personality following bodily death. Not coincidentally the very physicists who were, to one degree or another, interested in psychical research among the fiercest critics of scientific naturalism which, despite the claims of Huxley, Tyndall others to distance themselves from charges of materialism, they still considered "materialistic" because it seemed to violate a belief, engendered by a strong Christian faith, in the idea that the cosmos was suffused by mind and spirit.[71] This position was

articulated by Lord Rayleigh who told a correspondent in 1911 that "I have never thought the materialist view possible" and by Lodge, who vigorously opposed the "materialistic monism" of Ernst Haeckel and others by showing how energy conservation —which the naturalists believed ruled out free will — was not violated by the idea of material body being guided by life, mind or some other immaterial agent.[72]

As Section 7 will show, there is plenty of evidence supporting Wynne's contention that late-Victorian British physicists used the ether was a weapon against "scientific naturalism" insofar as this physical concept could be interpreted as a weapon against the view that the cosmos was devoid of mind and spirit, and that the sciences were entirely secular enterprises. It is much more difficult, however, to sustain Wynne's supposition that "Cambridge School" physicists were, either directly or indirectly, staunch opponents of *other* aspects of scientific naturalism: the promotion of "new conceptions of scientific education", the "professionalisation" and specialisation of the sciences, the importance of precision rather than imagination in the sciences, and the attempt to expunge from the sciences entities that could not be "empirically observed".[73] Since these aspects of scientific culture were shared by scientific naturalists *and* "Cambridge School" physicists, I want to argue that we cannot regard them as significant parts of emerging intellectual and social context to which ether theorising was an implicit reaction.

Studies made in the past few decades have blurred the boundaries between scientific naturalists and "Cambridge School" physicists. They challenge the claim that scientific naturalists were wholehearted advocates of the specialisation of the sciences and moreover, demonstrate the central parts played by Maxwell, Rayleigh, Stokes and other genuine Cambridge physicists in promoting, to the chagrin of some

reactionary dons, the teaching of such specialist "industrial" subjects as heat, electricity and magnetism in the ancient varsity.[74] Even closer to the "professionalisers" were Barrett, FitzGerald, Lodge and Stewart insofar as they spearheaded the teaching of industrially important and specialised scientific subjects in industrial cities, they became involved in nationwide attempts to promote scientific and technical instruction, and they upheld the moral and utilitarian benefits of such training.[75] The latter physicists, as well as Maxwell, Stokes, Tyndall and others, were rubbed shoulders at the Physical Society of London, an organisation that can be seen as an attempt by professors, teachers, and other practitioners of physics to identify themselves as scientific specialists and "professionals".[76] Like most late-Victorian scientific practitioners, the physicists that Wynne located in a "Cambridge School" held in the very least ambiguous positions on the specialisation of the sciences. We saw in Section 2 that FitzGerald urged the need for unity in the sciences, but he was not the only leading physicist who expressed this view but also helped to create and promulgate specialised scientific enterprises.

Maxwell's and Tyndall's membership of the Physical Society of London is one of many ways in which those key representatives of Cambridge physics and of scientific naturalism become difficult to distinguish. The picture is much more complicated than one contrasting Maxwell, the anti-utilitarian opponent of precision, to Tyndall, the utilitarian opponent of imagination. Maxwell and Tyndall agreed that scientific research was useful for its own sake and was crucial for Britain's industrial progress. In his *Treatise on electricity and magnetism* (1873) Maxwell recognised the crucial utilitarian value of "pure science" because the global telegraphic network gave "commercial value" to accurate electrical measurements while the diffusion of "electrical knowledge" among the growing community of electricians and "practical

men" underpinned the "general scientific progress of the whole engineering profession".[77] Maxwell also emphasised that the industrialised scientific research practices at Cavendish could also be linked to the moral function of Cambridge pedagogy. The accurate determination of the British Association standard of electrical resistance was thought to result in more efficient electric telegraph networks and provide better estimates of the physical characteristics of the electromagnetic ether, whose perfect continuity he believed fulfilled the moral role of showing that no part of the cosmos was bereft of the "symbols of the manifold order of His kingdom".[78] In the same period, Tyndall was making equally ambiguous remarks about the values of scientific knowledge.[79] He agreed that it was the fount of industrial progress, explaining that "Behind all our practical applications, there is a region of intellectual action to which practical men have rarely contributed, but from which they draw all their supplies". But for Tyndall the original inspiration of such intellectual "supplies" was not a "calculation of utility".[80] As he explained a few years earlier, scientific knowledge was a "great means of culture", a "thing profitable in itself, and requiring no practical application to justify its pursuit".[81] The reason why he wanted people to take science into their hearts was not as a "servant as Mammon […] but as the strengthener and enlightener of the mind of man".[82]

The example of Maxwell highlights the importance of precision measurement for most Victorian physicists, not least those in the "Cambridge School". His and Rayleigh's attempt to produce a robust standard of electrical resistance, as well as Crookes's measurement of the viscosity of rarefied gases and the spectra of new chemical elements, Lodge's construction of a highly sensitive interferometer to measure the minute dragging of ether by a rapidly rotating disk, and Barrett and Stewart's promotion of the virtues of precision measurement in pedagogical contexts,

illustrate how much this feature of experimental practice mattered to these leading physicists.[83] Just as we can easily link Wynne's "Cambridge School" to precision measurement, so we can easily link scientific naturalism to the imagination. When late-Victorian physicists sought to imagine the invisible worlds suggested by their experimental researches they often followed the example of John Tyndall whose celebrated 1868 address on "The scientific use of the imagination" was widely read by Victorian scientists.[84] Tyndall's example of using analogies, metaphors and other non-empirical strategies to represent such intangible entities as the ether was admired by other scientific naturalists and some "Cambridge School" physicists including Maxwell who, despite misgivings about the popularising strategies of the Royal Institution professor, explained to a close friend in 1871 that he was "busy writing a sermon on colour and Tyndalising my imagination up to the lecture point".[85]

Another entity for which late-Victorian physicists exercised much imagination was the atom. Wynne's analysis makes the atom central to the "non-ether, 'corpuscular'" cosmology of the naturalists, a cosmology apparently symbolising and legitimating a social order fragmented owing to lack of a cohesive force supplied by an unseen spiritual domain. As we have seen the ether an integral part of the cosmology of scientific naturalists, but atomism, like the ether, sits poorly with the naturalists' supposed adherence to empiricism and positivism. There were many late-nineteenth century scientists who doubted the existence of atoms because such entities, like the ether, defied empirical observation.[86] Wynne cites FitzGerald's 1896 critique of Wilhelm Ostwald's energeticism to illustrate the preference of the "Cambridge School" for metaphysics over empiricism, but FitzGerald was actually defending the metaphysical *virtues* of atomism: for him, hypotheses of atoms and other unobservable entities were as important to the British scientist as were "dry

catalogue of facts" because such a practitioner needed "emotion", "enthusiasm" and "human interest" in his science.[87]

7. BEYOND THE WYNNE THESIS

The foregoing sections demonstrate the major empirical and interpretative problems with Wynne's thesis. His "Cambridge School" includes many non-Cambridge physicists and elides differences among physicists, inside and outside Cambridge, regarding such questions as the "material" constitution of the ether and the legitimacy of psychical research. The contrast between the "Cambridge School" and scientific naturalists is also too sharp. Scientific naturalists certainly did not adopt a "non-ether" cosmology and were associated with several trends — the push for scientific education, the professionalisation of the sciences, and the importance of precision — that were also valued by "Cambridge School" physicists. At least one reason for this was that the latter school includes figures such as Barrett, Crookes, and Lodge whose backgrounds, training and career paths put them closer to the bourgeois and industrial worlds of Tyndall than those of aristocratic Oxbridge dons.

Wynne's "social" explanation of the ether views of late-Victorian physicists is now much more difficult to sustain. We cannot *assume* that, despite technical arguments to the contrary, the ether remained important to late-Victorian physicists because it fulfilled the need of a Cambridge-based intellectual elite for natural symbols of a desired social unity and Christian morality. The remainder of this paper shows how closer attention to historical evidence forces us to move beyond Wynne and develop a more nuanced picture of the connections between physicists, ethers, and late-Victorian religion and politics. By broadening the scope of the analysis to

include Cambridge and non-Cambridge physicists, and by embracing broader conceptions of the ether, I show that the mysterious medium was used explicitly and implicitly to express a range of positions on political and religious issues of the period.

The following analysis is based on the writings of the Cambridge-trained physicists Larmor, Maxwell, G. F. C. Searle, George Gabriel Stokes, Peter Guthrie Tait, and J. J. Thomson, as well as the non-Cambridge practitioners Barrett, FitzGerald, Lodge, Stewart, and Frederick Trouton. There is no doubt that other physicists envisioned extra-scientific uses of the ether, but few did so as explicitly as these practitioners.[88] This list does not include all those identified by Wynne as "Cambridge School" because not all physicists in that putative group expressed strong views about the ether — though they doubtless upheld the need for its existence — and certainly do not appear to have drawn religious or political messages from it. Lord Rayleigh, for example, seems like a promising case for Wynne's thesis, but I have excluded him because, despite having intimate connections with conservative politics, moral philosophy and the SPR (he was a Tory peer, his brothers-in-law included Arthur Balfour and Henry Sidgwick, and he, like Balfour and Sidgwick, was an SPR president), he does not appear to have envisioned extrascientific uses of the ether.[89]

The physicists selected for analysis span approximately three generations and in many ways constitute a natural group: they discussed each others' work in private and public exchanges, they often worked in the same laboratory or university, many were related as teacher and pupil, they rubbed shoulders at scientific, philosophical, and religious societies, and they often visited each others' homes. For example, Lodge was close scientific allies with Barrett, FitzGerald and Larmor; Stewart taught

Thomson who, in turn, guided Searle's work at Cambridge; and Stewart and Stokes shared interests in solar physics and Christian apologetics. Many gained the reputation, frequently self-created, of conservativism in scientific matters. Thus, in 1900 Larmor explained that the new methods of aethereal physics, to which he had himself largely contributed, represented a "conservative position" because they were based on the successful British tradition of dynamical physics; and thirteen years later, Lodge urged a "conservative attitude" towards relativity because he believed it was important to avoid "uprooting and removal of landmarks" such as Newtonian mechanics.[90]

Several other characteristics of this group can be immediately delineated and which provide the crucial contexts for understanding late-Victorian physicists' extrascientific uses of the ether. Like many leading Victorians, they were devout Christians although they represented different protestant branches of, and held occupied different positions on, the faith, from the Church of England (Challis and Searle), the Anglican Church of Ireland (FitzGerald and Stokes) and presbyterian (Maxwell, Stewart, and Tait), to Congregationalist (Barrett), "liberal" Christian (Lodge), and Christian opponents of Anglo-Catholicism and ritualism (Thomson and Rayleigh respectively).[91] In a period when many scientific naturalists' attacked alliances between science and religion, all counted religious scientists, clergymen, and theologians among their intellectual allies, many vigorously repudiated the argument that there was a conflict between the revelations of the sciences and Christian faith, and some engaged in "good works" from writing for evangelical periodicals to participating in Christian organisations.[92] Like Arthur Balfour and many other conservative intellectuals, they voiced profound fears of the moral and social consequences that would follow if materialism, rationalism, secularism, and other

systems of belief succeeded in eroding Christian practices and teachings.[93] Stewart and Tait's *Unseen universe* sought to show that "modern" scientific views of matter, energy and ether were compatible with Christian teachings on the spiritual life and therefore could combat the "materialist statements made nowadays" by Tyndall and others.[94] Their fears for the moral implications of the latter worldview were made clear in the 1878 edition of the work: "Take away all hope of a future state", they warned, "appear to demonstrate, if not with absolute certainty, yet with an approach to it, that such a condition of things is antagonistic to well-understood scientific principles, and we feel certain that the effect upon humanity would be simply disastrous".[95] Although Maxwell had several reasons for disliking Stewart and Tait's work, his own writings shared their view that the deterministic uses to which Tyndall and other scientific naturalists was putting theories of matter and energy had to be challenged, and that the Christian conception of free will (to which he was strongly attached) was consistent with a profounder interpretation of physical laws.[96] Someone who would have respected the anti-determinist and anti-materialistic goals of the *Unseen universe* was Stokes. Like Stewart and Tait he openly expressed his fear of the consequences of a waning belief in a future spiritual life. As Vice-President of the Christian Evidence Society, he warned in 1892 that the only way to avoid the growth of moral and religious laxity engendered by the "violent declamations of secularists and free-thinkers" was "earnest and incessant proclamation of the reasonableness of the fundamental truths of Christianity, and the validity of the evidence on which they rest".[97]

Stokes's religious and scientific views were much respected by many pious scientists outside Cambridge. Like Stokes, Barrett and Lodge questioned the scientific credibility and feared the moral implications of evolutionary biology, and

used the sciences to revitalise faith in Christian spirituality and safeguard public morality.[98] Barrett occasionally discussed religious matters with Stokes and echoed the Cambridge physicist when he insisted that knowledge of a universe transcending that of gross matter was a potent way of saving those "yearning for some deliverance from the meshes of materialism" or who had as their motto "Let us eat, drink, and study evolution, for tomorrow we die".[99] Lodge certainly agreed with Stokes that one of the biggest threats to public morality was secularism but many of his solutions to the problem would have displeased such a religious and scientific conservative as Stokes.[100] As Bowler points out, Lodge emerged as an outspoken proponent of "liberal" Christianity which challenged "those aspects of Christianity that were believed to be no longer compatible with the scientific worldview" which for Lodge meant the "liberalisation of the Christian message rather than a rejection of it" as well as a critical approach to what he judged outdated, incomprehensible and tedious rituals.[101] Like Stokes, Lodge sought to bolster confidence in a universe "permeated by life and mind" through interpretations of ether physics and the notion of evolution "directed" by Divine agency; but he diverged radically from the traditionalist Stokes in seeking to build his mission from radical reinterpretations of Christian doctrines and appeal to the controversial results of psychical research.[102] Larmor may not have had Lodge's skills in engaging with popular audiences, but he had the power to affect the law on the very educational and moral subjects that mattered so much to Lodge. As Member of Parliament for Cambridge University, he promoted the social benefits of Protestant-led Oxbridge and the union of Great Britain and Ireland, he argued for the need to maintain religious education in all schools, and he fiercely opposed the disestablishment and disendowment of the Church of England which he feared "must

involve disorganisation of many valuable features of our public life, while it would cripple grievously the religious life of the community".[103]

The example of Larmor spectacularly illustrates the fact that late-Victorian physicists were not just aware of political views, but actively campaigned for them, often to the point of seeking and gaining a parliamentary seat. As we saw in Section 4, most physicists vigorously promoted the development of scientific and technical education which often put them at odds with conservatives in Oxbridge colleges, the Anglican Church and the press. There were, however, a much larger range of political issues on which physicists expressed clear opinions, and it was on some of these issues that prompted them to turn the ether into a metaphor for a desired polity. One key issue was the government of Ireland, in particular the hugely controversial attempt by late-Victorian and Edwardian Liberal administrations to grant partial self-government or "Home Rule" to Ireland, the power being divided between the mainly industrial, loyalist and Protestant North of Ireland and the largely rural, nationalist and Catholic population in the South. Greta Jones has recently noted the "long campaign against home rule among a significant section of scientific opinion" in Great Britain and Ireland from the late 1880s until the electoral victory of Sinn Féin in 1918.[104] These scientists — including leading Cambridge physicists and scientific naturalists — adopted the conservative position of a large number of late-Victorian intellectuals and statesmen, including those Cambridge-educated or Cambridge-based figures, Balfour, Seeley, and Sidgwick.[105] Like most opponents to Home Rule they perceived the policy as a threat to the integrity of the empire and a desertion of loyalist landowners to belligerent farmers, but they also feared that it would lead to scientific research and training being oppressed by Catholicism.[106] Given the Irish roots of many leading late-Victorian physicists it is not surprising that were particularly

hostile towards Home Rule. It was politically so consequential that two physicists opposed on a host of cosmological and other scientific questions, William Thomson and John Tyndall, found themselves making the same move from Liberal to Liberal-Unionist camps.[107] It was one of the main issues on which Larmor and Stokes fought their respective campaigns for the parliamentary seat of Cambridge University: both won their battles, with Stokes representing the Conservatives from 1887–1891, and Larmor the Unionists from 1911–22, a position that sparked Larmor's friendship with Arthur Balfour.[108] Like most of the intellectuals who staffed the Protestant-dominated Trinity College Dublin, FitzGerald firmly backed the Union, believing that the Catholics who dominated Southern Ireland, and who were pressing increasingly vigorously for Home Rule, were too irrational and superstitious to rule themselves. In the early 1890s, in the midst of the brewing political storm over W. E. Gladstone's proposed second Home Rule bill and during his ongoing campaign to spread scientific and technical instruction in Ireland, FitzGerald promised to leave his homeland if Gladstone got his way and declared to Lodge that "Home Rule = Rome Rule".[109]

Among leading English-born physicists, Home Rule found many opponents including James Prescott Joule, Rayleigh, Stewart, Tait, and J. J. Thomson.[110] But its supporters included two of the strongest links between physics and psychics — Barrett and Lodge. In 1886 Barrett explained to the Liberal prime minister W. E. Gladstone that he believed the solution to sectarian conflict was for all parties to experience the "discipline of self-government" and to be forced to collaborate in a local legislature, while 1915 Lodge urged that Ireland should be "left free to develop its own genius without coercion".[111] On Ireland, and a range of other political issues, they diverged from conservatives in politics, philosophy and the sciences. Urban poverty and social strife prompted some of Barrett's fiercest outbursts. Some twenty

years after landing his professorship in Dublin, he lamented to Lodge that the city was "the most Godforsaken spot on this earth" with skirmishes between the "rabidly bigoted" Protestants and Catholics, and worse the "bottomless misery & poverty" of the "infinite drinking classes" partly caused by the brewers, distiller and publicans whose commercial success won them a seat in the House of Lords.[112] For this reason, Barrett devoted much of the time to a plethora of worthy causes in Dublin from alleviating the condition of the poor to quashing religious hatred.[113] Lodge wrote even more about the appalling condition of the destitute, and published much on the threats posed by rampant commercialism and materialism to what he considered the fundamental Christian values of brotherhood and unselfishness. In the early 1900s, for example, he identified selfishness, greed, and "self-satisfied stupidity" as the "Satans with which the Church should be fighting" and developed an argument, much appreciated by the Fabians Sidney and Beatrice Webb and the Socialist Keir Hardie, that the solution to the problems of urban decay lay in the use of private wealth for the common good.[114]

8. ETHERS OF RELIGION

The previous section highlighted some of the religious and political issues that mattered most to our select group of late-Victorian physicists. To what extent were conceptions of the ether used to articulate responses to these issues? Let us deal with religion first. The thirty years since the publication of Wynne's paper have produced many fine studies that considerably deepen our understanding of how physicists from a range of academic backgrounds used the ether as part of their mission to vanquish unbelief and to encourage conviction in a range of Christian teachings from the reality of miracles and the future spiritual life to the claim that the universe was the product

of Divine intelligence. My main purpose here is to show how this work, as well as many other examples drawn from my more recent research, provides a more satisfactory basis for Wynne's proposed link between ether and an unseen domain of mind, spirit and God.

The most notorious attempt in the late nineteenth century to spiritualise the ether was undoubtedly Stewart and Tait's anonymous best-seller, the *Unseen universe* (1875). In this explicitly anti-materialistic work the ether was part of a complex argument showing the compatibility of science — in particular the "principle of continuity", that "guide of all modern scientific advance" which allowed one state of the universe to be reconciled with an antecedent state — and the widespread (and to the authors, legitimate) Christian belief in a future spiritual state.[115] The ether was configured as the luminiferous medium "*plus* the invisible order of things, so that when the motions of the visible universe are transferred into the ether, part of them are conveyed as by a bridge into the invisible universe, and are there made use of or stored up".[116] In order to act as a sink for the dissipated energy of the visible universe, the ether had have one of the properties of ponderable matter — friction — for which Stewart and Tait believed they and others had provided strong experimental evidence.[117] The vortex structures in the ether that William Thomson and others considered possible origins of material atoms provided the crucial part of the mechanism by which human thoughts (treated as forms of motion in matter) were transmitted, via a succession of increasingly rarefied vortex atoms, to a "spiritual or invisible body", which survived the death of the material body and which seemed to exist in an unseen and super-etherial universe having the properties of the Divine — infinite energy and stability.[118] This was one of many ways in which Stewart and Tait believed the ether gave scientific credibility to Christian doctrines that seemed

incredible on the basis of the "principal of continuity". The Resurrection, miracles and the origin of life did not violate this principle, they held, because all such apparently supernatural occurrences could be considered as flows of energy via the continuous etherial channel from the unseen.

George Gabriel Stokes was sufficiently sympathetic to the goal of the *Unseen universe* that he helped Tait with the work's scriptural references, but he would not have approved of its argument because, as he warned in 1892, he did not believe that natural science could "demonstrate or even render probable" the survival of the soul following bodily death.[119] Nevertheless, he maintained that natural sciences could "remove the apparent incredibility" of such a metaphysically important claim "so as to leave the mind open to weigh any evidence in favour of survival that may come from a totally different quarter".[120] One of the ways in which Stokes thought the sciences could clear the mind of sceptics was by drawing analogies between the ether and scriptural truths. In his Gifford lectures of 1893, for example, he explained that George Green's elastic solid model of the ether predicted the existence of longitudinal pulses that travelled at a velocity "which may be deemed instantaneous" and which led to the contemplation of "an intelligent Will as pervading the whole universe".[121] Elsewhere in the same lectures he warned that just as it would have been folly, and detrimental to the study of optics, if physicists had rejected the ether simply because it was unknown and whose existence could only be proved indirectly, so it was folly to reject supernatural phenomena that seemed at first sight incredible or difficult to verify by the methods of physical science.[122]

Stokes's analogy between ether wave propagation and the passage of Divine will undoubtedly owed something to the view of one of his intellectual heroes, the Cambridge polymath William Whewell, whose *Astronomy and general physics*

considered with reference to natural theology (1830) identified the ether as the "great and active agent in the work of the universe" whose crucial role in enabling life on earth suggested that it had been made by a "most wise and good God".[123] Natural theological and theistic uses of the ether found supporters among a succession of Cambridge scientific dons long after Whewell's death. In 1873, the clergyman and Plumian professor of astronomy and experimental philosophy James Challis, argued that since the ether vanquished the "materialistic" view that bodies interacted across empty space and because its properties and laws were comprehensible it supported the belief in a cosmos that was a "vast and wonderful mechanism" created by Divine intelligence and power.[124] In the same year, one of the most famous attendees at Challis's professorial lectures Maxwell, opposed experimental evidence of a "wonderful medium" and action-at-a-distance theories and interpreted its capacity to fill all space, its "infinite continuity", its provision of light to man and its role in showing the "absolute unity" of the metric system of the cosmos as support for the notion of Divine omnipotence.[125] The providentialist lesson drawn by Whewell and Maxwell was upheld, albeit more subtly, by J. J. Thomson who in 1909 observed that the ether was "not a fantastic creation of the speculative philosopher" but "as essential to us as the air we breathe" because it conveyed to humanity "gifts from the sun". Thomson reinforced the moral of this survey of the latest research in the relationship between matter and ether by concluding with the phrase, "'Great are the Works of the Lord'".[126] One of the most important figures in shaping the practical skills of physics students in Thomson's Cavendish Laboratory was G. F. C. Searle, the son of an Anglican vicar whose strong Christian faith extended to the practise of spiritual healing.[127] At the meeting of the Pan-Anglican Congress in 1908 Searle made a Whewellian link between the ether, *qua* a continuous and unifying medium, and its

intelligent designer. He explained that the "facts of optics and electromagnetism compel us to recognise the existence of an all-pervading medium to which the name ether has been given", a "substance" that "binds the whole universe together". Moreover, it was this "evidence of the unity of the universe" that "leads us to the conviction that the whole universe, the ether included, is the work of a single Creator".[128]

The spiritual uses to which Barrett and Lodge put the ether were much more complicated. They certainly agreed with Stokes, Searle and Thomson that the unifying power of the continuous ether suggested the existence of an intelligent directing power in the cosmos: in 1894, for example, Barrett explained that the ether illustrated the "transcendent unity of nature" whose true significance lay in the unifying Divine mind underlying such "material" links; and it was because the ether seemed to have none of the imperfections associated with matter and attributes of the divine — perfect continuity and capacity to be "universal connecting link" of the cosmos that Lodge later aggrandized it as the "living garment of God".[129] However, Barrett and Lodge diverged considerably from physicists inside and outside the SPR in also making the ether part of an argument for the credibility of psychical phenomena. In the 1880s and 1890s Barrett and Lodge thought telepathy might be analogous to sensitive flames, aetherial telegraphy, and other physical systems exhibiting resonance, a less physicalist position than that of Crookes, FitzGerald, Heaviside, Samuel Tolver Preston and others who speculated that telepathy might actually involve ultra-high frequency ether waves from the brain of the "agent" inducing resonance in the brain of the "percipient".[130] By the early twentieth century, however, Barrett and Lodge were prepared to draw only loose analogies between telepathy and physical forms of resonance, mainly because of evidence that the

strength of telepathic impressions, unlike that of physical transmissions, seemed to transcend time and space and thus undermine the idea that telepathy was an etherial or any other physical process.[131] Nevertheless, they maintained that the ether, with its extraordinary properties, could fulfil spiritual and, *pace* Stokes, Searle, and Thomson, psychical functions. Both emphasised that the tendency of physics circa 1900 was towards vanquishing the materialistic image given to it by Tyndall in the late nineteenth century. It was because the "really fundamental dynamics […] must have an ethereal and not a material basis", Lodge observed in 1900, that there was a good chance that life and mind, hitherto excluded from the dynamics of matter in motion, could be accommodated within a "more general scheme of physical science".[132] Barrett and Lodge sought to bring the psychical and spiritual within the realms of physical science by emphasising how different ether was from ordinary matter. Since gross matter was known to be vehicle of life, contended Barrett, then the "imperceptible, imponderable, infinitely rare and yet infinitely elastic all-pervading kind of matter" called ether was, owing to its likely greater responsiveness to Divine will, even more likely to be the provenance of life, including the unseen intelligences that Barrett was convinced manifested themselves in spiritualist séances.[133] Developed in the early decades of the twentieth century, Lodge's hypothesis of the "etherial body" built on the speculations of Barrett as well as the *Unseen universe*, even though Stewart and Tait's book did not seek to provide an etherial mechanism for, and give credibility to, spiritualistic communication.[134] Lodge held that since all interactions between material bodies took place via the ether — including the very cohesive forces which held matter together — then it was possible to associate with every material body an etherial body. For animate objects, the etherial body had a "psychic significance" at least as much as the material constituent: indeed, it was

precisely because it suffered from none of the "temporal disabilties" of the material body that the etherial body and its associated psychic function, survived bodily death and was then free to "lead a less abstracted and livelier existence".[135] Indeed, it was the etherial part of our bodies that Lodge believed constituted the permanent and real aspect of our being: it was this that he offered as an explanation of the invisible intelligences he believed had manifested themselves through spiritualist mediums and as something to make more intelligible the Christian idea of the spiritual body.[136]

Neither FitzGerald nor Larmor were ever so explicit in connecting the ether to metaphysical or religious questions, but such connections can be found. Hunt has shown that FitzGerald's attempt to reduce the ether to a form of pure motion in an incompressible fluid owed much to his belief that, following Bishop Berkeley, the cosmos reduced to forms of motion which were objective manifestations of a Divine thought.[137] Elsewhere, FitzGerald turned the puzzle of the ether's constitution into an argument against determinism. It was because he was "utterly puzzled by such an obviously infinitely simpler question as the constitution of the ether, infinitely simpler I mean than the possible methods of producing a virtuous being" that he considered certain biologists to be "[s]elf-sufficient fools" for insisting that nature, including human life, had to follow fixed physical laws.[138] Larmor agreed that the complexity of the ether was insignificant compared with that of organic systems and that dynamical laws — which he believed completely described the ether — were not arguments determinism and materialism. In an obscure appendix in *Aether and matter* he insisted that "mechanical determinateness […] need not involve molecular determinateness" because the mechanical principles that were so useful for understanding the ether and other systems undergoing no structural change could not be employed to understand the molecular changes causing the origin and development

of organic systems.[139] Keen that the physicist not be taken to be the "equivalent of a materialist", Larmor elsewhere hinted at the theistic implications of the ether.[140] In a 1906 lecture he explained that "the main support, the unfailing clue, of physical science is the principle that, Nature being a rational *cosmos*, phenomena are related on the whole in the manner that reason would anticipate".[141] As we saw in Section 3, simplicity was one of the reasons that Larmor gave for believing in the ether. A simple ether was clearly part of what Larmor considered the most reasonable human explanation of the cosmos, and thus the ether was part of how a rational intelligence would have designed the universe.

9. ETHERS OF POLITICS

We have seen that there was broad agreement among our group of physicists that the ether could be used to support Christian teachings on mind, spirit, and God, and indirectly, the Christian morality that followed from such a theistic conception of the cosmos. But to what extent did physicists see analogies between what they judged to be plausible etherial conceptions of the natural world and desirable social arrangements? Did the ether help them articulate their position on the political issues about which they felt so strongly?

FitzGerald may not have been as explicit as Lodge, Stokes and others in using the ether to support Christian spirituality, but he represents one of several plausible cases of a late-Victorian physicist teasing out the social implications of the unifying capacity of the ether. In March 1894 he published an analysis of "Physical science and its connections" that opened with a striking analogy between the corporate life of animals, social states, and the organisation of the sciences. "Progress consists in the

reconciling of apparent contradictions", he insisted, and the "corporate life" of organisms and civilised states could only progress through "intercommunication" between its constituent parts. For this reason, a civilised state with "interdependent specialised interests suffers from the incapacity or rapacity of its classes more than a company of Fuegans, each of whom can supply all his own wants". For FitzGerald science was progressing in the same way as civilised states: in general it needed intercommunication between its different disciplines and in particular it required that research done in physical science be collected, digested and distributed to the biologist, chemist and geologist. Of this research, none was more important than the "study of the properties of each kind of matter as related to energy and the ether" because this had "bearings on every department of science and on every practice".[142] The ether was a connecting link between the sciences that demanded elucidation and "strength" because without it scientific disciplines were in danger of becoming too specialised and suffering from undernourishment from other disciplines and "local turgescence and inflammation", which would damage the whole scientific "system".[143] The timing of FitzGerald's article suggests that "corporate life" may well have been a veiled reference to the Union of Great Britain and Ireland that he staunchly upheld. We saw earlier that by early 1894 FitzGerald was fiercely opposing Irish Home Rule and was painfully aware of one example of what he considered a rapacious class undermining the progress of a civilised state — the attempt by Irish Catholics and Nationalists to break connections with the British empire. It was only by maintaining the links between Britain and Ireland that he believed "corporate life" of the empire could progress. For this reason, FitzGerald's strong belief in an ether symbolised his staunch support for the Union. In at least one very important sense,

his solution to problems of politics and science was the same: attend to and strengthen the connecting links.

The ether supplied a different symbol for the Unionist position of FitzGerald's compatriot, Larmor. For Larmor, the ether seems to have symbolised the importance of traditional values over radical change in science and politics. Solutions to problems in physics and politics could often be most effectively solved by adhering to these traditions. As Warwick has shown, Larmor was keenly interested in the historical traditions of physics: *Aether and matter* and his semi-popular writings contained much historical analysis, and from the early 1900s he produced hagiographies and edited collections of the scientific papers of FitzGerald, William Thomson, Stokes and other Irish protestant ether builders whom he revered. An underlying message in these reconstructions was to show that the ether had evolved as an inevitable outcome of man's long search for a deeper understanding of the cosmos.[144] It was with the ether concept that Thomson, Stokes and others made substantial progress in physics, and Larmor sought to continue the tradition with his notion of an all-embracing dynamical ether. For these reasons he warned in 1900 that abandoning the "conception of discrete atoms and continuous Aether" was relinquishing something standing "in intimate relation with our modes of mental apprehension" of the world and the "abandonment of all the successful traditions" of physics.[145] It was because the ether stood for everything that Larmor thought was successful and worthy in science that he could not forgive the younger generation of physicists for championing relativity so ardently and forgetting "that Scoto-Irish School of physics which dominated the world in the middle of the [nineteenth] century".[146]

The abandonment of "successful traditions" was perilous in politics and science. Larmor upheld long-established protestant traditions of science (ether hypotheses) and society (Unionism) in which unification entailed progress. Like FitzGerald, he explicitly linked the unity of the social body and progress: his election manifesto, for instance, insisted that Britain's fiscal problems could only be solved by preserving the "most intimate connexion between the constituent parts of the Empire".[147] But the political project that mattered most to him was preserving the traditional link between Britain and Ireland that he believed underpinned progress. In the wake of the news, in March 1914, that British troops stationed at Curragh had chosen to resign their commissions rather than coerce Ulstermen into accepting Home Rule, Larmor wrote to the *Times*, emphasising his descent from an Ulster community who "proudly cherished and maintained the traditions of a glorious past" and that military occupation would never "break the spirit of British freedom which has burned in Ulster for three centuries". A few years earlier he had stood up in the House of Commons and warned that abandoning Ulstermen to the "Nationalist menace" meant challenging the "spirit" of commerce and of education that had brought industrial prosperity to the Protestant industrial North of Ireland, a tradition that he believed would bring "political content" to the whole of Ireland.[148]

The view that Protestant industry and intellectual endeavour had been and would continue to be the key to Ireland's success was implicit in a 1914 work of Frederick Trouton, a Trinity College Dublin physicist who had assisted FitzGerald and Larmor with their researches. Warwick has described how in the early 1900s Trouton tried unsuccessfully to produce experimental evidence of the motion of the earth relative to the ether and repudiated fellow physicists for adopting the "Principle of Relativity" and giving up the search for ether drag which he believed, once

detected, would provide mankind with a formidable source of energy and economic progress.[149] In a paper submitted to the 1914 meeting of the British Association he insisted this abandonment would not have happened in fifty years earlier when a "purely dynamical basis was expected for the full explanation of all phenomena", an implicit reference to the heyday of the leading Scoto-Irish architects of dynamical ether theories, Maxwell, Stokes, and William Thomson. These men were the "sturdy protestants of science", Trouton declared, "while we of the present day are much more catholic in our scientific beliefs, and in fact it would seem that nowadays to be used to anything is synonymous with understanding it".[150] For Trouton, the ether symbolised the virtues of Protestantism — the insistence on achieving understanding through construction of sturdy dynamical models and pursuit of the industrial benefits derived from such an understanding — while relativity theory symbolised the vices of Catholicism: just as Catholics only accepted the reality superstitions because they had grown accustomed to them, so modern physicists only accepted relativity because they had got used to it. Among the individuals whom Trouton doubtless included among the "present day" scientists who had betrayed the "protestant" tradition in abandoning the attempt to measure and utilise ether drag was Larmor. This was partly mistaken, however, since Larmor, unlike Einstein and his champions, very much identified himself as part of the "Scoto-Irish" tradition of constructing unifying dynamical ether theories and maintained that the ether drag could be detected, albeit with experimental arrangements much more sensitive than those used by Trouton.[151]

Trouton probably would not have identified either his former colleague in Dublin, Barrett, or Lodge, as examples of the modern "catholic" scientists given that Barrett had not kept abreast of the "new physics" and Lodge had emerged as the most vociferous British critic of relativity. But to Trouton, Barrett's support for Irish Home

Rule might well have made him look like a modernist in politics, if not in science. Barrett's confidence that sectarian conflict would disappear once the warring factions collaborated and learned the discipline of self-government stemmed partly from his belief, revealed most strikingly in his energetic promotion of plebeian education and self-help schemes, in the capacity of human beings to learn how to improve themselves and live harmoniously. It is also possible that this owed something to his belief in the "underlying unity that exists throughout Nature". What created the "solidarity of the universe" was gravitation and the ether, which permitted exchanges of radiation between every body in the cosmos.[152] By the 1890s Barrett was convinced that the universe in which solidarity ruled embraced the psychical as well as the physical domains. Although he repudiated the strict analogy between telepathy and etherial or any other physical form of influence, he still saw the ether as a natural symbol of the solidarity that could exist in the social world. Indeed, it was by the cultivation of a power roughly analogous to ether waves — telepathy — that he thought human beings could develop their capacity for reconciliation and understanding. As he explained in 1895, this long evolutionary process would mean that "involuntary sharers in one another's pleasures and pains, the brotherhood of the race would not be a pious aspiration or a strenuous effort, but the reality of all others most vividly before us".[153]

It is perhaps unsurprising that the most outspoken British champion of the ether should also be the figure who provides the most numerous examples of the ether being used in political and social discourse. In popular lectures and books, Oliver Lodge envisioned the ether as the literal and metaphorical means of achieving social harmony. In *Talks about wireless* (1925) this architect of communication by etherial or wireless telegraphy alluded to the bloody conflict of the First World War (in which

his son Raymond had been killed) when he explained that the "power of rapid communication will surely conduce to better understanding among the nations, and will lead in due time to the much-desired but long-delayed era of universal peace".[154] Insofar as the ether was also the means by which Lodge increasingly believed the human soul survived bodily death and communicated with the living, then it was also an integral part of his spiritualistic view that social progress could be aided by communion with those that had passed over. It was implied in his view that spirit communications showed that "humanity is not isolated in the Universe" and put us in "close and affectionate touch with a higher order of beings, who realise our difficulties, help our struggles" and who "by co-operating with us, they can contribute to the advancement of the whole".[155]

The political issues on which Lodge was moved to publish substantial works were those that prompted implicit and explicit uses of the ether as a political metaphor. In *Public service versus private expenditure*, a lecture delivered in 1904 and published by the Fabian Society the following year, Lodge developed years of preoccupation with the condition of Britain's poor and the distribution of wealth, a concern that led him to a position closer to Socialist friends such as Sidney and Beatrice Webb than his Tory colleagues inside and outside the SPR. It insisted that "corporate or combined expenditure achieves a greater result, not only for the whole, but actually for the individual" and tied such a vision to the Christian virtues of self-sacrifice and unselfishness that Lodge promoted more explicitly elsewhere.[156] I want to suggest that Lodge's explicit identification of wealth as one of the "forces of nature" which can "increase our own power and influence and effective *momentum* in the world" provides a hint that his socialist vision was partly justified by a conception of the physical world — specifically, a Maxwellian view of force.[157] By this time

Lodge penned this work he was optimistic that *all* the forces of nature, not just those associated with heat, light, electricity and magnetism, originated in states of the ether.[158] Just as Lodge and his Maxwellian colleagues sought to raise the social benefits of the forces of electricity and magnetism by understanding the common etherial realm whence they originated, so Lodge believed the force of wealth was better exploited if located in a common body — the community.

Lodge concluded his lecture by comparing Britain unfavourably to the "magnificent spectacle of Japan to-day: the State above the individual; common good above personal good; sacrifice of self and devotion to the community". The danger with Britain was that it seemed to be loosing what Japan had in abundance — a national "soul" or "spirit of unselfishness".[159] The possibility that Lodge saw the ether not just as the actual vehicle of the individual soul, but the symbol of a nation's soul is suggested by a far more potent political work, *The war and after* (1915), published at the height of Lodge's fiercest response to the champions of Einstein's relativity theory.[160] It was an attack on two senses in which Germany had apparently lost the sense of spirit of the world: its scientists had abandoned the ether for relativity and the whole nation was suffused with the "war spirit and war caste" and descending into a "civilisation without morality, with no wide outlook, no elevation of purpose, no loftiness of soul, no perception of beauty, no veneration or recognition of anything higher than the State".[161] The two were intimately related. After insisting that the "right appreciation of the universe" attended to both matter and ether, he warned of the perils of loosing sight of the latter: "there is always a danger", he warned,

> lest the material becomes dominant and overpower the spiritual, whose existence may be denied. For just as in the physical universe matter is obvious and insistent to our senses; whereas the ether, no matter how substantial it may really be, is intangible and elusive, so that its existence is disbelieved in and denied by the specifically scientific

philosophy of modern German physicists; so it is also in the larger scheme to which these things are an allegory.[162]

The reason why German physicists had abandoned the ether was an allegory of the "larger scheme" of the whole nation loosing its "spiritual sense" and abandoning the teaching of one of its national heroes, Georg Wilhelm Hegel, that ""Above and beyond the State there is the spirit of the World, which is also the spirit of God, before which all things are judged"".[163] The lesson was to understand how the natural world confirmed the Christian spirit of brotherhood and showed how co-operation led to strength and harmony, whether this referred to the evidence of "unconscious cooperation and mutual aid" in the animal kingdom or the unifying power of the ether of space.[164]

10. CONCLUSION

This paper has suggested that conceptions of the ether developed by leading late-Victorian physicists had complex relationships with the broader religious and political contexts within which they were produced. This controversial hypothesis of physicists proved immensely useful in their attempts to express positions on major issues of the period. It was used in different ways by different physicists who, fearing the moral and social consequences of the apparently dwindling appeal of Christian doctrines, turned to their field of expertise to make plausible the reality of the spiritual aspects of nature: it showed a unified, ultimately simple, and providentially designed cosmos; it provided a warning against the summary dismissal of miracles and Divine agency; it was a plausible habitat of the soul and a useful analogy for comprehending telepathic communion; and it was used to show that mechanical science was not an argument against the possibility of immaterial agency in nature. It was also used in

subtly different ways by physicists who took envisioned slightly different solutions to the fragmentation of the empire and community life: its unifying power and basis in the successful tradition of dynamical physics was a metaphor for maintaining the unifying power and successful tradition of the Union of Great Britain and Ireland, and its status as a medium above and giving solidarity to the domain of ponderable matter made it a powerful natural symbol for the importance of sharing and humanity over greed and individualism. It was partly because the ether could be so easily manipulated to fulfil these different and related desiderata that it appealed to several British physicists well into a period when colleagues at home and abroad were content to abandon the mysterious medium.

It is difficult to estimate how much the epistemic value of the ether was raised by its use in moral and political contexts. Such uses were certainly not *necessary* for a belief in the ether since there were plenty of British physicists — for example, Hicks, Fleming, S. P. Thompson, and William Thomson — who maintained a strong belief in the existence of the ether but did not put it to extrascientific uses. For these physicists, as for the individuals analysed in this paper, the primary arguments for the ether remained a combination of the aesthetic, empirical, "philosophical", and physical. At the very least, we can conclude from this paper that the ether was even more valuable to a significant number of late-Victorian physicists because it could be used to express political and religious views that they held dear, a move that was possible partly because for these practitioners the ether embodied a range of deeply held principles and values that cut across distinctions between physics, politics and religion. For Larmor and Trouton, adherence to solid and successful traditions mattered in science and politics; for Barrett, FitzGerald, Larmor, and Lodge progress through unity and community applied to political and scientific problems; and for

Lodge, Stewart, Stokes, and Tait, the tolerance of claims about the cosmos that might seem puzzling at first but which ultimately made it more comprehensible was an important principle in religion and physics.[165]

Several studies have explained why the ether concept dwindled in twentieth century physical sciences, leaving Larmor and Lodge as practically the only British defenders of this nineteenth century construct, physicists who were reputedly considered by younger colleagues as "on the shelf" or otherwise out of touch.[166] Warwick has shown how experimental physicists trained in Cambridge hardly used the concept of the ether after 1900 and found relativity increasingly useful because it was preoccupied with measurement, while mathematical physicists in the ancient varsity saw the notion of an absolute etherial frame of reference as "ontologically meaningless" in their own practices of electrodynamics.[167] Swenson has suggested that, following the long series of inconclusive ether drift experiments, physicists increasingly regarded the ether as a philosophical question or "metaphysical" concept unimportant to their physical enquiries and practices.[168] This is undoubtedly true, but the increasing association between ether and metaphysics became "pejorative" only insofar as metaphysics was not appropriate to scientific practices.[169] As well as a handful of physicists who held that the ether was required by later developments in electrodynamics (including Larmor's successor as Cambridge's Lucasian professor of mathematics, Paul Dirac), there were many physicists and electrical engineers who considered speculations on the nature and functions of the ether important for addressing the metaphysical questions that they pondered outside the contexts of their routine scientific and engineering work. The situation was captured by Alexander Pelham Trotter, a Cambridge-trained physicist turned electrical engineer, who in 1926 pointed out that the although the ether remained a "speculative hypothesis" and that

Einstein's followers considered the ether "useless, unwarranted, and unnecessary […] most of us who have listened to Sir Oliver Lodge's broadcast lectures on "Ether and Reality", or have read his recent books on the subject, probably feel that the ether is not to be dismissed by a summary negation".[170] Similarly, four years later, the Professor of Electrical Engineering at Armstrong College in Durham, William Mundell Thornton, explained in a lecture on the "Scientific background of the Christian creeds" that the ether could be "dispensed with — so far as equations go" but was still useful in comprehending God. Possibly drawing on Stewart and Tait, Lodge and Einstein's identity between mass and energy, Thornton concluded that while was inconceivable to suppose that God's supposed infinite energy caused a finite result — the material universe — the ether, whose total energy "must be immensely greater than that of the matter of the universe", provided a suitable "abode of God".[171]

Trotter's and Thornton's views, and moreover, the success of Lodge's books, wireless broadcasts and lectures, testify to the fact that well into the twentieth century there remained considerable audiences for speculations on the ether's broader functions, irrespective of its vanishing presence in cultures of experimental and theoretical physics. Many of the sources analysed in this paper were aimed at a general or non-specialist readership and it was from the *Unseen universe*, Stokes's Gifford lectures, British Association addresses, and similar works that many late-Victorians and Edwardians received their first detailed understanding of the latest speculations on matter, ether, and energy. It is not clear how much such works shaped readers' political and religious views or their belief in an ether *per se,* but they certainly helped sustain a debate well into the twentieth century, in which both scientists and non-scientists engaged, on the uses to which physics in general and the

ether in particular could be put in answering broader questions about life, death, and humanity.[172]

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[6] Bruce Hunt to Barry Barnes, 15 July 1983 and 2 August 1983, copies kindly supplied to author by Bruce Hunt. I thank Bruce Hunt for permission to cite these letters. Wynne's paper reappeared as 'Natural knowledge and social context: Cambridge physicists and the luminiferous ether', in B. Barnes and D. Edge (eds.), *Science in context: readings in the sociology of science* (Milton Keynes, 1982), 212–231.

[7] Brian Wynne, 'Note of correction' accompanying a letter from Brian Wynne to Bruce Hunt, 27 January 1985, copy supplied to author by Bruce Hunt.

[8] For an excellent example of how a more localised notion of the social — the programme of mathematical training in Victorian Cambridge — transforms our

understanding of the production of esoteric knowledge see A. Warwick, *Masters of theory: Cambridge and the rise of mathematical physics* (Chicago, 2003).

[9] J. Golinksi, *Making natural knowledge: constructivism and the history of science* (Cambridge, 1998), xi.

[10] Wynne, *op. cit.* (ref. 5), 168, 181.

[11] Wynne, *op. cit.* (ref. 5), 169.

[12] Wynne, *op. cit.* (ref. 5), 181.

[13] Wynne, *op. cit.* (ref. 5), 170–173.

[14] For 'scientific naturalism' see F. Turner, *Between science and religion: the reaction to scientific naturalism in Victorian England* (New Haven, 1974), 8–37.

[15] Wynne, *op. cit.* (ref. 5), 175.

[16] Wynne, *op. cit.* (ref. 5), 176, 180.

[17] Wynne, *op. cit.* (ref. 5), 178–179.

[18] Wynne, *op. cit.* (ref. 5), 178–179.

[19] Wynne, *op. cit.* (ref. 5), 183.

[20] Wilson, *Kelvin and Stokes*, *op. cit.* (ref. 3), 17–40; Warwick, *Masters of theory*, *op. cit.* (ref. 8), 427; S. Goldberg, 'In defense of ether: the British response to Einstein's special theory of relativity, 1905–1911', *Historical studies in the physical sciences*, ii (1970), 89–125, 121–125; J. Cross, 'Integral theorems in Cambridge mathematical physics, 1830–55', in P. Harman (ed.), *Wranglers and physicists: studies in Cambridge mathematical physics in the nineteenth century* (Manchester, 1985), 112–148.

[21] Hunt to Barnes, 15 July 1983, *op. cit.* (ref. 6); Wynne, 'Note of Correction', *op. cit.* (ref. 7).

[22] For Barrett see R. Noakes, ‘‘The bridge which is between physical and psychical research’: William Fletcher Barrett, sensitive flames, and spiritualism, *History of science*, xlii (2004), 419–464. For FitzGerald see B. Hunt, *The Maxwellians* (Ithaca, 1991), 5–47. For Stewart see G. Gooday, ‘Sunspots, weather, and the *Unseen universe*: Balfour Stewart’s anti-materialist representations of “energy” in British periodicals’, in G. Cantor and S. Shuttleworth (eds), *Science serialized: representations of the sciences in nineteenth-century periodicals* (Cambridge MA, 2004), 111–148.

[23] For Lodge see O. Lodge, *Past years* (London, 1931); Wilson, ‘The thought of late-Victorian physicists’, *op. cit.* (ref. 3); Hunt, *Maxwellians*, *op. cit.* (ref. 22), 24–47, 73–107.

[24] Warwick has emphasised the role of local cultures of mathematical training in creating idiosyncratic styles of scientific puzzle-solving: Warwick, *Masters of theory*, *op. cit.* (ref. 8).

[25] For Crookes’s spiritualistic investigations see R. Noakes, ‘‘Instruments to lay hold of spirits’: technologising the bodies of Victorian spiritualism’, in I. Morus (ed.), *Bodies/machines* (Oxford, 2002), 125–163, 140–148. For Crookes’s work on electrical discharge see R. Dekosky, ‘William Crookes and the fourth state of matter’, *Isis*, lxvii (1976), 36–60.

[26] Wynne, *op. cit.* (ref. 5), 172.

[27] I. Falconer, ‘Corpuscles, electrons and cathode rays: J. J. Thomson and the ‘discovery of the electron’’, *British journal for the history of science*, xx (1987), 241–276, 243–251; O. Darrigol, *Electrodynamics from Ampère to Einstein* (Oxford, 2000), 265–313.

[28] Compare the cultures of Cambridge physics analysed in Warwick, *Masters of theory*, *op. cit.* (ref. 8), 357–399 and Dong-Won Kim, *Leadership and creativity: a history of the Cavendish Laboratory, 1871–1919* (Dordrecht, 2002), 93–186. See also A. Warwick, 'The sturdy protestants of science: Larmor, Trouton, and the earth's motion through the ether', in J. Buchwald (ed.), *Scientific practice: theories and stories of doing physics* (Chicago, 1995), 300–343, 311.

[29] J. F. Moulton, 'Matter and ether [1877]', *Proceedings of the Royal Institution of Great Britain*, viii (1875–1878), 335–346; J. H. Poynting, 'Presidential address to the mathematical and physical section of the British Association (Dover), 1899', in Poynting, *Collected scientific papers* (Cambridge, 1920), 599–612; O. Lodge, obituary notice in Poynting, *Collected scientific papers*, ix–xiv, xiv. For Poynting's scepticism of ether models see Hunt, *Maxwellians*, *op. cit.* (ref. 22), 94–95.

[30] L. Stephen and F. Pollock (eds), *Lectures and essays by the late William Kingdon Clifford* (London, 1886), 139–140, 161–179.

[31] Wynne, *op. cit.* (ref. 5), 178.

[32] Wynne, *op. cit.* (ref. 5), 223.

[33] Hunt to Barnes, 2 August 1983, *op. cit.* (ref. 6).

[34] Wynne, *op. cit.* (ref. 5), 183; Hunt to Barnes, 3 August 1983, *op. cit.* (ref. 6).

[35] J. Tyndall, *Light and electricity: notes of two courses of lectures given before the Royal Institution of Great Britain* (New York, 1871), 125.

[36] Noakes, *op. cit.* (ref. 22), 423–429; Lodge, *Past years*, *op. cit.* (ref. 23), 78.

[37] J. Larmor, *Aether and matter: a development of the dynamical relations of the aether to material systems on the basis of the atomic constitution of matter*

(Cambridge, 1900), vi; Joseph Larmor, 'A dynamical theory of the electric and luminiferous medium—part III: relations with material media [1897]', in J. Larmor, *Mathematical and physical papers*, 2 vols, (Cambridge, 1929), i, 624–639, 629, 631. For Larmor see Warwick, *Masters of theory*, *op. cit.* (ref. 8), 357–398, idem., ''That universal aethereal plenum': Joseph Larmor's natural history of physics', in K. Knox and R. Noakes (eds), *Newton to Hawking: a history of Cambridge University's Lucasian professors of mathematics* (Cambridge, 2003), 343–386, Hunt, *Maxwellians*, *op. cit.* (ref. 22), 209–239; J. Buchwald, *From Maxwell to microphysics: aspects of electromagnetic theory in the last quarter of the nineteenth century* (Chicago, 1985), 133–173.

[38] R. McCormmach, 'H. A. Lorentz and the electromagnetic view of nature', *Isis*, lxi (1970), 459–497; Buchwald, *op. cit.* (ref. 36), 133–258. For Cunningham see Warwick, *Masters of theory*, *op. cit.* (ref. 8), 399–442.

[39] W. F. Barrett, 'Science and spiritualism', *Light*, xiii (1894), 539–540, 559–561, 571–572, 583–585, 595–597, 572; [B. Stewart and P. G. Tait], *The unseen universe or physical speculations on a future state* (London, 3rd edn, 1875), 70, 116; G. G. Stokes, *Burnett lectures. On light* (London, 1892), 15; J. J. Thomson, 'Address', *Report of the seventy-ninth meeting of the British Association for the Advancement of Science, Winnipeg; 1909* (London, 1910), 15, 17.

[40] H. Stein, ''Subtler forms of matter' in the period following Maxwell', in Cantor and Hodge, *op. cit.* (ref. 1), 309–340, 317.

[41] Hunt, *Maxwellians*, *op. cit*. (ref. 22), 217.

[42] H[orace] L[amb], 'The ether of space', *Nature*, cxxxii (1909–10), 271.

[43] O. Lodge, 'Continuity', *Report of the eighty-third meeting of the British Association for the Advancement of Science. Birmingham: 1913* (London, 1914), 3–

42, 27; O. Lodge, *My philosophy: representing my views on the many functions of the ether of space* (London, 1933), 192.

[44] Lodge, *My philosophy*, *op. cit.* (ref. 43), 190–91.

[45] A. Dolbear, *Matter, ether and motion: the factors and relations of physical science* (London, 1899), 352.

[46] Wynne, *op. cit.* (ref. 5), 181.

[47] Warwick, 'Sturdy protestants', *op. cit.* (ref. 28), 311.

[48] A. Warwick, 'On the electrodynamics of moving bodies and the principle of relativity in British physics, 1894–1919', (unpublished PhD dissertation, University of Cambridge, 1989), 65.

[49] Warwick, 'On the electrodynamics', *op. cit.* (ref. 48), 110.

[50] Buchwald, *op. cit.* (ref. 36); Hunt, *Maxwellians*, *op. cit.* (ref. 22); Darrigol, *op. cit.* (ref. 27), 137–264.

[51] T. Preston, *The theory of light* (London, 2nd edn, 1895), 30–31.

[52] J. Larmor, 'Aether', in *Encyclopaedia Britannica*, 29 vols. (Cambridge, 11th edn, 1910–1911), i, 292–297, 293.

[53] A. Einstein, 'The ether and relativity' in *Sidelights on relativity* tr. by G. Jeffrey and W. Perrett (New York, 1922), 3–24.

[54] O. Lodge, 'Physics and psychics', *Morning Post*, 26 October 1927, 11. Cf. Larmor, *Aether and matter*, *op. cit.* (ref. 37), 273; J. J. Thomson, *Recollections and reflections* (London, 1936), 432.

[55] I. Morus, *When physics became king* (Chicago, 2005), 181.

[56] Stokes, *Burnett lectures*, *op. cit.* (ref. 39), 80; Larmor, 'The physical aspect of the atomic theory [1908]', in Larmor, *Mathematical and physical papers*, *op. cit.* (ref. 37), ii, 344–372, 372.

[57] J. Larmor, 'Address', in *Report of the seventieth meeting of the British Association for the Advancement of Science held at Bradford in September 1900* (London, 1900), 613–628, 618.

[58] This built on decades of scientists' public rhetoric stressing the need for the unity of the sciences: see R. Barton, ''Men of science': language, identity, and professionalization in the mid-Victorian scientific community', *History of science*, xli (2003), 73–119. For later manifestations of this desired unity of the science see E. Hiebert, 'The state of physics at the turn of the century', in M. Bunge and W. Shea (eds), *Rutherford and physics at the turn of the century* (New York, 1979), 3–22, 4–7

[59] Lodge, 'Continuity', *op. cit.* (ref. 43), 27. See Warwick, 'On the electrodynamics', *op. cit.* (ref. 48), 97.

[60] O. Lodge, *Modern views of electricity* (London, 1889), 307.

[61] G. F. FitzGerald, 'Physical science and its connections', *Science progress*, i (1894), 1–11, 2; O. Lodge, 'Lord Kelvin's philosophy', *Nature*, lxxviii (1908), 198–199, 199.

[62] Wynne, *op. cit.* (ref. 5), 178.

[63] In 1921 the SPR's Honorary Secretary, Eleanor Sidgwick tried successfully to persuade Thomson to remain a vice-president of the society by explaining that the post was "purely honorary" and did not require Thomson to attend meetings: it was enough that Thomson's name on the society's publications implied a "general approval of our objects and methods". E. M. Sidgwick to J. J. Thomson, 6 January 1921, J. J. Thomson Papers, Trinity College Library, JJT H22/1. For Rayleigh and psychical research see Rayleigh, 'Presidential address', *Proceedings of the Society for Psychical Research*, xix (1919–20), 276–290. Thomson detailed his interests in psychical research in Thomson, *op. cit.* (ref. 54), 147–163.

[64] For the work of Gurney, Myers and Sidgwick see A. Gauld, *The founders of psychical research* (London, 1968) and J. Oppenheim, *The other world: spiritualism and psychical research in Britain, 1850–1914* (Cambridge, 1985), 111–158.

[65] Thomson and Stokes cited in [W. T. Stead], 'The response to the appeal', *Borderland*, i (1892), 10–23, 17, 19.

[66] J. C. Maxwell, 'Idiotic imps [1853]', in L. Campbell and W. Garnett, *The life of James Clerk Maxwell with selections from his correspondence and writings* (London, 2nd edn, 1884), 341–343, 342; Maxwell, 'Paradoxical philosophy', in W. Niven (ed.), *The scientific papers of James Clerk Maxwell*, 2 vols (Cambridge, 1890), ii, 756–762, 762.

[67] J. Larmor to O. Lodge, 7 January 1901, Oliver Lodge Papers, University College London (hereafter 'OJL-UCL'), MS Add. 89/65.

[68] A. Chattock, 'Experiments in thought-transference', *Journal of the Society for Psychical Research*, viii (1897–98), 302–307.

[69] G. F. FitzGerald to O. Lodge, 11 December 1894, OJL-UCL, MS Add. 89/35; FitzGerald to Barrett, 23 April 1882 cited in W. F. Barrett et al. 'First report of the "Reichenbach" committee', *Proceedings of the Society for Psychical Research*, i (1882–83), 230–237, 236. Citation from FitzGerald cited in [Stead], 'The response to the appeal', *op. cit.* (ref. 65), 19.

[70] O. Heaviside to O. Lodge, 11 January 1895, 28 January 1895, and 26 August 1896, OJL-UCL, MS Add. 89/50, ff. 91–92 and 100; J. Perry to O. Lodge, 29 August 1891, OJL-UCL, MS Add. 89/82; J. Thompson and H. Thompson, *Silvanus Philips Thompson: his life and letters* (London, 1920), 332; S. P. Thompson, 'A

physiological effect of an alternating magnetic field', *Philosophical Transactions of the Royal Society*, lxxxii B (1909–10), 396–398.

[71] C. Smith, *The science of energy: a cultural history of energy physics in Victorian Britain* (London, 1998), 239–267; Wilson, *Kelvin and Stokes*, *op. cit.* (ref. 4), 74–99. For scientific naturalists' critical attitude towards materialism see B. Lightman, *The origins of agnosticism: Victorian unbelief and the limits of knowledge* (Baltimore, 1987), 22–26; R. Barton, 'John Tyndall, pantheist: a re-reading of the Belfast address", *Osiris*, iii (1987), 111–134; S. S. Kim, *John Tyndall's transcendental materialism and the conflict between religion and science in Victorian England* (Lewiston, 1996).

[72] Rayleigh cited in Lord Rayleigh [R. J. Strutt], *John William Strutt Third Baron Rayleigh* (London, 1923), 361; O. Lodge, *Life and mind: a criticism of Professor Haeckel's "Riddle of the Universe"* (London, 1905).

[73] Wynne, *op. cit.* (ref. 5), 171, 173. For the problems of using 'professional' and 'professionalisation' to describe the activities of Victorian scientists see Barton, ''Men of science'', *op. cit.* (ref. 58), and J. Morrell, 'Professionalisation', in R. Olby et al (eds.), *Companion to the history of modern science* (London, 1990), 980–989.

[74] For Huxley's aversion to narrow scientific education see A. Desmond, *Huxley: evolution's high priest* (London, 1997), 247–248; P. White, *Thomas Huxley: making the 'man of science'* (Cambridge, 2003), 94–97. For industrial and specialised sciences at Cambridge see Kim, *op. cit.* (ref. 28) ; S. Schaffer, 'Late Victorian physics and its instrumentation: a manufactory of Ohms', in R. Bud and S. Cozzens (eds), *Invisible connections: instruments, institutions, and science* (Bellingham, 1992), 23–56; Schaffer, 'Accurate measurement is an English science', in M. N. Wise (ed.), *The values of precision* (Princeton, 1995), 135–172; Schaffer,

'Physics laboratories and the Victorian country house' in C. Smith and J. Agar (eds), *Making space for science: territorial themes in the shaping of knowledge* (London, 1999), 149–180; D. B. Wilson, 'Experimentalists among the mathematicians: physics in the Cambridge Natural Sciences Tripos, 1851–1900', *Historical studies in the physical sciences*, xii (1982), 325–371, and idem., 'Arbiters of Victorian science: George Gabriel Stokes and Joshua King' in Knox and Noakes, *op. cit.* (ref. 37), 343–386, 312–315.

[75] For Stewart see G. Gooday, 'Precision measurement and the genesis of physics teaching laboratories in Victorian Britain', (unpublished PhD dissertation, University of Kent, 1989), chapter 7. For Barrett see Noakes, *op. cit.* (ref. 22), 429–431. For Lodge see N. Clow, 'The laboratory of Victorian culture: experimental physics, industry, and pedagogy in the Liverpool laboratory of Oliver Lodge, 1881–1900' (unpublished Ph.D. dissertation, Harvard University, 1999). For FitzGerald see G. Jones, 'Scientists against Home Rule', in D. Boyce and A. O'Day (eds), *Defenders of the Union: a survey of British and Irish Unionism* (London, 2001), 188–208, esp. 191 and N. Whyte, *Science, colonialism and Ireland* (Cork, 1999), 46–50.

[76] For the Physical Society see R. Moseley, 'Tadpoles and frogs: some aspects of the professionalisation of British physics, 1870–1939', *Social studies of science*, vii (1977), 423–46 and G. Gooday, 'Teaching telegraphy and electrotechnics in the physics laboratory: William Ayrton and the creation of an academic space for electrical engineering in Britain 1873–1884', *History of technology*, xiii (1991), 73–111, 83–84.

[77] J. C. Maxwell, A *treatise on electricity and magnetism*, 2 vols (Oxford, 3rd edn, 1891), i, vii–viii.

[78] J. C. Maxwell, 'On action at a distance [1873]', in Niven, *op. cit.* (ref. 66), ii, 311–323, 322.

[79] For further analysis see T. Gieryn, *Cultural boundaries of science: credibility on the line* (Chicago, 1999), 37–64.

[80] J. Tyndall, *Six lectures on light delivered in America in 1872–1873* (New York, 3rd edn, 1901), 222.

[81] J. Tyndall, 'On radiant heat in relation to the colour and constitution of bodies', in J. Tyndall, *Fragments of science: a series of detached essays, addresses, and reviews*, 2 vols, (London, 6th edn, 1879), i, 74–95, 94.

[82] Tyndall, *Six lectures on light*, *op. cit.* (ref. 80), 245.

[83] For Maxwell and Rayleigh see Schaffer, 'Late Victorian physics', *op. cit.* (ref. 74) and Schaffer, 'Accurate measurement', *op. cit.* (ref. 74). For Lodge see B. Hunt, 'Experimenting on the ether: Oliver J. Lodge and the great whirling machine', *Historical studies in the physical sciences*, xvi (1986), 111–34. For Barrett see Noakes, *op. cit.* (ref. 22). For Stewart see Gooday, 'Precision measurement', *op. cit.* (ref. 75), chapter 7.

[84] J. Tyndall, 'The scientific use of the imagination', in Tyndall, *Fragments*, *op. cit.* (ref. 81), ii, 101–136.

[85] Maxwell to C. J. Monro, 15 March 1871, in Campbell and Garnett, *op. cit*. (ref. 66), 289. For Tyndall's use of the imagination to represent the ether see Tyndall, 'The scientific use of the imagination', *op. cit.* (ref. 81), 106–109. For Huxley's use of the imagination see White, *op. cit.* (ref. 74), 94–97.

[86] S. Brush, *The kind of motion we call heat: A history of the kinetic theory of gases*, 2 vols (Amsterdam, 1976), i, 90–102 and 274–99; D. Knight, *Atoms and elements: a study of theories of matter in England in the nineteenth century* (London,

1967); M. J. Nye, 'The nineteenth-century atomic debates and the dilemma of an 'indifferent hypothesis'', *Studies in history and philosophy of science*, vii (1976), 245–268.

[87] G. F. FitzGerald, 'Ostwald's energetics', in J. Larmor (ed.), *The scientific writings of the late George Francis FitzGerald* (Dublin, 1902), 387–391.

[88] For example, I omit discussion of Samuel Tolver Preston (d. 1917) a British-born civil engineer turned writer on physics who, in *Physics of the ether* (London, 1875) and elsewhere, built on Le Sage's theory of gravity to develop a hypothesis in which action between material bodies originated in the motion of ultramundane molecules which themselves constituted the ether. Although his work was often cited by Maxwell, Lodge and other leading physicists, he remained well outside such scientific circles partly because of his training and reclusive existence in Britain and Germany. Preston's views on the ether seem to have been only tangentially connected with his religious views. His adherence to an ether *qua* mechanical continuum for vanquishing action at a distance in physics may well have reflected his bitter hostility to traditional Christian doctrines that broke the chain of cause and effect between human motive and action and which discouraged moral responsibility. Unlike the trained British physicists considered here, he ridiculed the idea of a future immortal spiritual existence as unproven and irresponsible because it filled people's minds with mysterious ideas and diminished their desire to increase happiness in this world. See S. T. Preston, 'On method in causal research', *Philosophical magazine*, ix (1880), 356–367 and S. T. Preston, 'Science and sectarian religion' in S. T. Preston, *Original essays* (London, 1884), 19–51.

[89] This may, and probably will, change if and when scholars are granted access to the full range of Rayleigh family papers at Terling Place near Witham in Essex.

[90] Larmor, 'Address', *op. cit.* (ref. 57), 617; Lodge, 'Continuity', *op. cit.* (ref. 43), 19.

[91] For Searle see [Anon.], 'G. F. C. Searle', *Times*, 18 December 1954, 8. For Stokes see Wilson, *Kelvin and Stokes*, *op. cit.* (ref. 3), 74–99. For Maxwell see Smith, *op. cit.* (ref. 71), 211–218. For Tait see C. G. Knott, *Life and scientific work of Peter Guthrie Tait* (Cambridge, 1911). For Barrett see Noakes, *op. cit.* (ref. 22), 423–425. For Challis, FitzGerald and Stewart see *Oxford Dictionary of National Biography* <http://www.oxforddnb.com>, accessed 19 September 2005. For Lodge see Bowler, *op. cit*. (ref. 3), 96–101. For Rayleigh see Rayleigh, *Third Baron Rayleigh*, *op. cit*. (ref. 72), 360–361. For J. J. Thomson see Lord Rayleigh [R. J. Strutt], *The life of Sir J. J. Thomson* (Cambridge, 1942), 283–284.

[92] The religious views of many in this group were quoted in the important late-Victorian survey of the Christian views of leading scientists: A. Tabrum, *Religious beliefs of scientists* (London, [1910]).

[93] Jacyna, *op. cit.* (ref. 5); B. Lightman, 'Victorian sciences and religions: discordant harmonies', *Osiris*, xvi (2001), 343–366, 349–355.

[94] [Stewart and Tait], *op. cit.* (ref. 39), vii.

[95] B. Stewart and P. G. Tait, *The unseen universe or physical speculations on a future state* (London, 8th edn, 1879), 3.

[96] Smith, *op. cit.* (ref. 71), 211–267.

[97] G. G. Stokes and Earl of Halsbury [H. S. Giffard], 'Infidelity and how to meet it', *Times*, 8 December 1892, 10.

[98] W. F. Barrett, 'The demons of Derrygonnelly', *Dublin University magazine*, xc (1877), 692–705, 702 and 'The psychic factor in evolution', *The quest*, ix (1917–18), 177–202; Lodge, *Life and mind*, *op. cit.* (ref. 72).

[99] [W. F. Barrett], 'The phenomena of spiritualism', *Nonconformist*, xxxvi (1875), 934–937, 937; Barrett, 'The demons', *op. cit.* (ref. 98), 702.

[100] O. Lodge, *The substance of faith allied with science. A catechism for parents and teachers* (London., 2nd edn, 1907), viii.

[101] Bowler, *op. cit.* (ref. 3), 96.

[102] O. Lodge, *Man and the universe: a study of the influence of the advance in scientific knowledge upon our understanding of Christianity* (London, 5th edn, 1909), 24.

[103] J. Larmor, 'Sir Joseph Larmor's address', *Times* 25 January 1911, 9.

[104] Jones, *op. cit.* (ref. 75), 188.

[105] For Balfour, Sidgwick and Seeley on Home Rule see B. Schultz, *Henry Sidgwick: eye of the universe* (Cambridge, 2004), 563–568, 608–609; R. Foster, *Modern Ireland 1600–1972* (Harmondsworth, 1989), 415–428; Jacyna, *op. cit.* (ref. 5), 19–23.

[106] Jones, *op. cit.* (ref. 75), 188.

[107] A version of Stokes's election manifesto was published as G. G. Stokes, 'To the members of the Senate of the University of Cambridge', *Cambridge chronicle*, 11 November 1887, 4. Larmor's election manifesto appeared as Larmor, 'Sir Joseph Larmor's Address', *op. cit.* (ref. 103). On Tyndall's Unionism see A. Eve and C. Creasey, *Life and work of John Tyndall* (London, 1945), 264–268. For William Thomson's Unionism see C. Smith and M. N. Wise, *Energy and empire: a biographical study of Lord Kelvin* (Cambridge, 1989), 802–811.

[108] W. Morton, 'Sir Joseph Larmor', *Proceedings of the Belfast Natural History and Philosophical Society*, 1942–43, 82–90, 89; A. Balfour, 'Mr. Balfour's views', *Times*, 8 February 1911, 7.

[109] G. F. FitzGerald to O. Lodge, 11 July 1892 and 27 February 1893, OJL-UCL, MS Add. 89/35. For further discussion see Jones, *op. cit.* (ref. 75), *passim* and Whyte, *op. cit.* (ref. 75), 46–50.

[110] D. Cardwell, *James Joule: a biography* (Manchester, 1989), 262; Knott, *op. cit.* (ref. 91), 36; Rayleigh, *Third Baron Rayleigh*, *op. cit.* (ref. 72), 43; B. Stewart, 'Politics and the presidency of the Royal Society', *Nature*, xxxvii (1887–1888), 76; J. J. Thomson to R. Threlfall, circa July 1886, J. J. Thomson Papers, Cambridge University Library Add. 7654 (henceforth 'JJT–CUL'), T10. I owe the latter reference to Katrina Dean.

[111] W. F. Barrett to W. E. Gladstone, 4 April 1886, Gladstone Papers, British Library, Add. 44496, f. 165; O. Lodge, *The war and after. Short chapters on subjects of serious practical import for the average citizen in A.D. 1915* (London, 1915), 201.

[112] W. F. Barrett to O. Lodge, 13 December 1892, Oliver Lodge Papers, Society for Psychical Research Archive, Cambridge University Library, SPR.MS.35/61.

[113] See Noakes, *op. cit.* (ref. 22), 430.

[114] Lodge, *Man and the universe*, *op. cit.* (ref. 102), 148. See also S. Webb to O. Lodge, 12 February 1905, Oliver Lodge Papers, Birmingham University Library (hereafter OJL-BUL), OJL 1/424/1; K. Hardie to O. Lodge, 15 October 1895, OJL-BUL, OJL 1/166/1.

[115] [Stewart and Tait], *op. cit.* (ref. 39), viii.

[116] [Stewart and Tait], *op. cit.* (ref. 39), 158–159. For discussion see Smith, *op. cit.* (ref. 71), 254–255 and Gooday, 'Sunspots', *op. cit.* (ref. 22).

[117] [Stewart and Tait], *op. cit.* (ref. 39), 119.

[118] [Stewart and Tait], *op. cit.* (ref. 37), 159.

[119] P. G. Tait to G. G. Stokes, 6 and 11 March 1875, Stokes Papers, Cambridge University Library, Add. 7646, T73–T74.

[120] G. G. Stokes, *Natural theology: the Gifford lectures delivered before the University of Edinburgh in 1893* (London, 1893), 57.

[121] Stokes, *Natural theology*, *op. cit.* (ref. 120), 33.

[122] Stokes, *Natural theology*, *op. cit.* (ref. 120), 1–26, 34, 46. See also Bowler, *op. cit.* (ref. 3), 92.

[123] W. Whewell, *Astronomy and general physics considered in relation to natural theology* (London, 1837), 138, 141. For discussion see Cantor, *op. cit.* (ref. 2).

[124] J. Challis, *An essay on the mathematical principles of* physics (Cambridge, 1873), 106–107.

[125] Maxwell, 'On action at a distance', *op. cit.* (ref. 78), 322.

[126] Thomson, 'Address', *op. cit.* (ref. 39), 15, 29.

[127] [Anon.], 'G. F. C. Searle', *op. cit.* (ref. 91).

[128] G. F. C. Searle, 'The modern conception of the universe', in *Pan-Anglican papers. Being problems for consideration at the Pan-Anglican Congress, 1908* (London, 1908), 1–8, 3, 7.

[129] Barrett, 'Science and spiritualism', *op. cit.* (ref. 39), 597; O. Lodge, *Ether and reality. A series of discourses on the many functions of the ether of space* (London, 1930), 155, 174, 179.

[130] W. F. Barrett, E. Gurney, and F. W. H. Myers, 'Thought-reading', *Nineteenth century*, xi (1882), 890–900, 900; O. Lodge, 'Experiments in thought-transference', *Proceedings of the Society for Psychical Research*, ii (1884–85), 189–200, 191; W. Crookes, 'Some possibilities of electricity', *Fortnightly review*, li (1892), 173–185, 176; O. Heaviside to O. Lodge, 28 March 1895, OJL-UCL, MS. Add. 89/50, f. 100; S. T. Preston, 'On the physics of thought reading', accompanying Preston to J. J. Thomson, 5 May 1893, JJT–CUL, P45; S. T. Preston, 'On the importance of experiments in relation to the mechanical theory of gravitation', *Philosophical magazine*, iii (5th Series) (1881), 391–393, 391; G. F. FitzGerald to S. T. Preston, 3 September 1890, FitzGerald Papers, Royal Dublin Society, 11/63.

[131] W. F. Barrett, 'Presidential address', *Proceedings of the Society for Psychical Research*, xvii (1901–3), 1–21, 19–20.

[132] O. Lodge, 'Scope and tendencies of physics', in A. Sedgwick et al., *The 19th century: a review of progress* (London, 1901), 348–357, 352, 354.

[133] Barrett, 'Science and spiritualism', *op. cit.* (ref. 39), 597.

[134] [Stewart and Tait], *op. cit.* (ref. 39), 42–43. For an example of Lodge's use of this work is Lodge, *My philosophy*, *op. cit*. (ref. 43), 224. For detailed discussion of Lodge's 'etherial body' see Wilson, 'The thought of late Victorian physicists', *op. cit.* (ref. 3).

[135] O. Lodge, 'Ether, matter, and the soul', *Hibbert journal*, xvii (1918–1919), 252–260, 258–259.

[136] Lodge, *Ether and reality*, *op. cit.* (ref. 129), 177.

[137] Hunt, *Maxwellians*, *op. cit.* (ref. 22), 98–100.

[138] FitzGerald cited in W. Barrett, 'The marginal regions of science', *Contemporary review*, civ (1913), 467–476, 470.

[139] Larmor, *Aether and matter*, *op. cit.* (ref. 37), 288.

[140] J. Larmor to O. Lodge, 31 May 1900, UCL-OJL, MS Add. 89/65.

[141] Larmor, 'The physical aspect', *op. cit.* (ref. 56), 350. For further discussion see Warwick, ''That universal aetheral plenum'', *op. cit.* (ref. 37), 368–369.

[142] FitzGerald, 'Physical science'. *op. cit*. (ref. 61), 1–2.

[143] FitzGerald, 'Physical science', op. cit. (ref. 61), 2.

[144] Warwick, ''That universal aethereal plenum'', *op. cit.* (ref. 37), 365–373.

[145] Larmor, 'Address', *op. cit.* (ref. 57), 619.

[146] Larmor cited in D'Arcy Thompson, 'Joseph Larmor, 1857–1942', *Year Book of the Royal Society of Edinburgh 1941–42* (Edinburgh, 1943), 11–13, 12.

[147] Larmor, 'Sir Joseph Larmor's address', *op. cit.* (ref. 103).

[148] J. Larmor, 'The story of province', *Times*, 23 May 1914, 5; Larmor reported in *Hansard's House of Commons debates*, xxxviii (5th ser.) (1912), 462. For the 'Curragh mutiny' see Foster, *op. cit.* (ref. 105), 469.

[149] This paragraph leans heavily on Warwick, 'Sturdy Protestants', *op. cit.* (ref. 28).

[150] F. Trouton, 'Address', *Report of the eighty-fourth meeting of the British Association for the Advancement of Science. Australia: 1914* (London, 1915), 285–290, 286.

[151] Warwick, 'Sturdy Protestants', *op. cit.* (ref. 28), 327.

[152] W. F. Barrett, 'Address by the president', *Proceedings of the Society for Psychical Research*, xviii (1903–4), 323–350, 336**.**

[153] W. F. Barrett, 'Dynamic thought', *Humanitarian*, vii (1895), 242–248, 245.

[154] O. Lodge, *Talks about wireless with some pioneering history and some hints and calculations for wireless amateurs* (London, 1925), x.

[155] O. Lodge, *Science and human progress* (London, 1926), 61.

[156] O. Lodge, *Public service versus private expenditure* (London, 1905), 3.

[157] Lodge, *Public service*, *op. cit.* (ref. 156), 4.

[158] See, for example, Lodge, 'Scope and tendencies', *op. cit.* (ref. 132), 352.

[159] Lodge, *Public service*, *op. cit.* (ref. 156), 10–11.

[160] For further discussion of Lodge, ether, and relativity see P. Rowlands, *Oliver Lodge and the Liverpool Physical Society* (Liverpool, 1990), 251–298; Warwick, 'On the electrodynamics', *op. cit.* (ref. 48), 105–109.

[161] Lodge, *War and after*, *op. cit.* (ref. 111), 65, 91.

[162] Lodge, *War and after*, *op. cit.* (ref. 111), 18.

[163] Lodge, *War and after*, *op. cit.* (ref. 111), 7, 18.

[164] Lodge, *War and after*, *op. cit.* (ref. 111), 54.

[165] A comparative analysis of the moral and political uses to which nineteenth and twentieth century German physicists put the ether may well lend support to this thesis, a possibility suggested by the metaphysical background of many nineteenth century German ether conceptions and the overt political uses that Nazi physicists such as Phillip Lenard made of the ether. For further discussion of these points see see M. N. Wise, 'German conceptions of force, energy, and electromagnetic ether: 1845–1880' in Cantor and Hodge, *op. cit.* (ref. 2), 269–307. For Lenard see K. Hentschel, *Interpretationen und fehlinterpretationen der speziellen und der allegemeinen relativitätstheorie durch zeitgenossen Albert Einsteins* (Basel, 1990).

[166] O. Lodge to J. A. Hill, 5 March 1928 in J. A. Hill (ed.), *Letters from Sir Oliver Lodge: psychical, religious, scientific and personal* (London, 1932), 222–225, 224.

[167] A. Warwick, 'Cambridge mathematics and Cavendish physics: Cunningham, Campbell, and Einstein's relativity 1905–1911. Part II: comparing traditions in Cambridge physics', *Studies in history and philosophy of science*, xxiv (1993), 1–25, 10–13; Warwick, *Masters of theory*, *op. cit.* (ref. 8), 427.

[168] L. Swenson, *The ethereal aether: a history of the Michelson-Morley-Miller aether-drift experiments, 1880–1930* (Austin, 1972), 228–245.

[169] Swenson, *op. cit.* (ref. 168), 231.

[170] A. Trotter, 'Illumination and light', *Journal of the Institution of Electrical Engineers*, lxiv (1926), 367–371.

[171] W. M. Thornton, *The scientific background of the Christian creeds. Riddell memorial lectures. Second series* (Newcastle, 1930), 17–18.

[172] See, for example, W. Hooper, *The universe of ether and spirit* (London, 1913); A. Powell, *The etheric double and allied phenomena* (London, 1925); J. Findlay, *On the edge of the etheric* (London, 1931).